RECORDS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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CONTENTS.

NUMBER 1.—FEBRUARY.

NUMBER 2.—MAY.

NUMBER 3.—AUGUST.

NUMBER 4.—NOVEMBER.

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OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] **1869.** **[May.**

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1868.

In reporting the progress and doings of the Geological Survey of India during the year 1868, I shall take each branch of our labors in the same order as I have for the most part observed on former occasions

Mr. W. T. Blanford has, during the whole of the year just past, been engaged with the Abyssinian Field-force, and since its return in arranging and examining the large collections he made during the expedition. Mr. Ormsby was compelled to leave for Europe early in the year, having suffered from exposure to the tropical sun. And Mr. Charles Oldham left on furlough in November. On the other hand, Mr. Tween returned to his duty in charge of the Museum here. Mr. Foote resumed his labors in Madras, and Mr. Theobald in Burmah. On the whole our numbers have been, during the past year, less reduced than usual in consequence of ill-health.

At the commencement of the year, I proceeded to the Madras Presidency to make enquiry on the spot into the facts regarding the asserted occurrence of coal close to the town of Juggiapett, or Battavole, near the Kistna River. For years it had been persistently repeated that coal had actually been raised in that neighbourhood, and this statement was maintained notwithstanding the fact that very many persons, deeply interested in the result and most anxious to confirm the discovery if possible, had visited the localities, but had entirely failed to find any trace of evidence that coal existed or was likely to exist. Its occurrence in this place would have been of such high importance, that I was desirous of visiting the place as soon as practicable; I had also received from the Madras Government an urgent request to enquire into the facts. This request had reached me at a time when field-work was not practicable, but I had promised to go there as soon as possible. I left Calcutta, therefore, early in January; and accompanied by the original propounder of the discovery, I visited carefully every locality which he indicated, and went generally over the district. I regret to state that I found no trace of the coal-bearing rocks; no signs of coal, or of any of its usual accompaniments, nor was I able to see a single spot where anything, in the slightest degree leading to the conclusion that coal did exist there, could be found. On the contrary, all these rocks are an unbroken and uninterrupted continuation of similar rocks which cover an enormous area in the districts of Kurnool, Kuddapah, and Guntoor to the south, and which, thoroughly exposed as they are in their many folds, contortions, and disturbances throughout this area, must have exhibited any beds of coal or coal-shale which possibly existed. But, neither in the Juggiapett country, nor over the many hundred square miles to the south, over which similar rocks extend and which have all been carefully examined, has any trace of such deposits been noticed. I was, therefore, compelled to believe that the statement of coal having been found at or near Juggiapett was either based upon an intentional deception practised on the original observer, or was a delusion.

From the vicinity of Juggiapett, I proceeded southward, devoting some time to carefully testing the accuracy of the geological mapping of a considerable area which had been previously examined by Mr. C. Oldham and Mr. King, and returned to Calcutta.

Towards the close of the year (December), I proceeded to Attok to examine the rocks under the River Indus, through which a tunnel drift had been carried, with a view to determine the practicability of enlarging this drift into a regular roadway. I had wished to accomplish this work earlier in the season, but as the tunnel was full of water, and was not pumped out until December, I was obliged to defer it. Having already reported in some detail on this question, I need not here enter into the facts, further than to state, there appeared nothing either in the structure or in the composition of the rock-masses to prevent the immediate enlargement of the drift with perfect safety, provided proper precautions were adopted, and the work were done at once. But that these precautions would render the cost of the tunnel, when completed, quite as great as that of a first class bridge, and that even then the accommodation to the traffic would certainly not be as great as that afforded by a bridge.

Subsequently, at the request of the Government of the Punjab, I examined with some care the range of hills near Futtyjung, extending southward from Cheerat, and in which petroleum had been obtained. I saw everything to lead to the conclusion that petroleum would be found over a large area in these orbitolite limestone rocks, although probably not in any very great quantities in one place. The best position for trials seemed fairly indicated, and these I noted. The probability would seem to be that limited reservoirs of this oil will be found at no great depth from the surface, although I am not very sanguine that they will prove very extensive in any one locality. Similar rocks occur again in a rudely parallel range to the east, and here also traces of earth-oil are seen; and it would appear very probable that supplies will be found extending over a large area in this part of the Punjab.

An examination of the Dhurmsala district, and also of the Goorgaon district near Delhi, was requested, with a view to determine the extent of deposits of kaolin said to occur in each. Looking, however, to the inaccessibility of both and their distance from any markets, which must prevent the economizing of this clay to any large extent; and also to the fact that, so far as any local demand existed, it was of no importance to determine at the present the *extent* of these deposits, their existence being known, I felt compelled to think this enquiry was of vastly less importance than others. And that, so far as any question of extent or amount of such deposits was concerned, a very much more satisfactory answer could be given after the whole districts had been gone over than after a rapid visit to one or two isolated localities. No mistake can be greater than to imagine that a geologist can, by a sort of intuition, arrive at a knowledge of facts bearing on such questions. This can only be acquired by a continuous and detailed investigation necessarily demanding time.

Bengal and Upper Provinces.—During the early part of the year just closed, Mr. Medlicott was engaged in the investigation of the western and southern flanks of the Garo Hills. So long since as 1842, Mr. Bedford, who had surveyed parts of this area, announced the occurrence of coal in the hills bordering the Bramahpootra River at the western extremity of the Garo Hills, near to a village called Harigaon, and other outcrops had been noticed further to the east in the Sumesurri River. The peculiarly favorable situation of these places, within easy reach of a great river, and in districts where fuel was otherwise not readily procurable, rendered it of high importance that the facts should be ascertained. It was also known that the rocks which accompany coal in the Khasia Hills extended to the west, and there was, therefore, a probability that the coal might also be found to extend in the same direction. It had long been hoped that a topographical survey of these hills would afford the means of recording carefully the geological observations, but as there appeared little likelihood of these hopes being realized within any reasonable time, and as meanwhile the question of the eastern and northern extension of the Eastern Bengal Railway was urgent, it was determined to examine the area, in such a general way as might be sufficient, without entering into minute detail, to solve the question satisfactorily of the probable amount and character of the coal which occurred there. Mr. Medlicott's report on the results of his examination having been published (*Records of the Geological Survey of India*, Part 1,1868, p. 11), it is unnecessary to enter into any detail here. It will be sufficient to state that he has shown that the spurious coal of the Garo Hills is geologically distinct from most of that known in the Khasia Hills; that, in all cases, this coal occurs near to the base of the whole stratified series within a few yards of the underlying crystalline rocks; while the coal itself is very poor, in one place mainly a resinous shale, in another, a thick bed of dark stiff clay with insignificant strings of lignite through it. Where in greatest quantity, it is described as a thick band of shale in the midst of which occurs the coal-seam: it is a good deal crushed, altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and sand; and contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a woody sound when struck, is very tough, and breaks with a large conchoidal fracture. It was obvious that whatever little use might be made of such deposits, if required on the spot, they were practically of no value as a source of fuel, for general purposes. It is most seriously to be regretted that the statements upon which expectations of coal had been founded should have proved to be so fallacious.

Having completed the cursory examination of these rocks, Mr. Medlicott devoted some time to a more careful examination of the Khasia Hills, for which portions of the topographical survey maps were ready. These very interesting hills had never before been visited by any of the officers of the survey at a time when it was possible to examine the lower parts of their steep slopes; and consequently, as pointed out long since, much remained to be done, before we could suppose that we possessed any true knowledge of their structure. Further, the full determination of the cretaceous age of the sandstones, &c., under Cherra Poonjee, *(Quar. Jour. Geol. Soc. London*, 1863, p. 524, Oldham, on cretaceous rocks in E. Bengal) which, in my own early description, in consequence of their apparent continuity and conformity, (the fossils collected having been lost at sea) had been grouped with the tertiary rocks above, rendered it necessary to carry out this separation in detail. Mr. Medlicott has been able to do much towards this, and in tracing out these rocks has been led to several very valuable conclusions, a brief summary of which has already appeared in the Records of the Survey. As soon as the topographical survey of these hills is completed, I hope to be able to have them examined in detail.

Later in the season, Mr. Medlicott having arranged for the several duties assigned to the assistants under his charge, was requested to take up the very important geological question of the extent and relations of the several series of sandstones, &c., associated in Bengal with the coal, as compared with those in Central India. With this object, making a rapid traverse of the Ranigunj field, and passing westwardly by the Hazareebagh fields, he has carried out the section across to Jubbulpore, and with very valuable results, which will tend much to a clearer understanding of the different groups or formations. In a new country, where the general relations of the rocks is quite unknown, it becomes necessary for each observer to form for himself a classification of the rocks he examines, grouping them into series or formations, and often giving to these sub-divisions local names. But as the examination of the country advances, it not unfrequently happens that such classification is proved to be of purely local type, and it is essential either to increase the sub-divisions or to bring several together into one larger group. Mr. Medlicott's traverse of this wide extent of country will go far, I believe, to remove, in several cases, the limited amount of confusion which had unavoidably arisen from the fact that previously the officers of the survey had been working at distant and isolated points.

Mr. Willson has completed the detailed examination of the district of Saugor in the Central Provinces, which he has connected with those of Dumoh and Jubbulpur to the east. Unfortunately the want of maps of the country lying to the west of Saugor district has prevented the extension of our examinations in that direction, as I was very desirous of doing, in order to join on the geological lines to those we have been for some time past steadily carrying southwards through the Gwalior and Rajpootana territories. The district of Saugor is mainly composed of trappean rocks, which are, in this parallel, the most northerly portion of the Great Deccan area of these ancient volcanic rocks. These rest upon Vindhyan rocks for the greater portion of their boundary.

Mr. Mallet has, during the early part of the year, completed the examination of the crystalline rocks of Bundlecund—being a continuation of his work of the previous year—so far as the area occupied by these rocks is comprised on sheet 70 of the Indian Atlas. The further explorations of this year have rather induced Mr. Mallet to abandon the idea of separating these rocks into two series as was suggested in 1866-67. The evidence, however, is even yet scanty, and not conclusive. And it must remain for more careful investigation when better maps, on a larger scale, of the Bijawur area become available. The maps, at present procurable, are too imperfect to admit of any close or searching examination and record.

During the recess, Mr. Mallet completed a full report on the Vindhyan rocks, so far as that widely spread formation is known in northern India up to the present. A general map has been compiled to illustrate this. This report has been sent to press. At the commencement of the working season in October 1868, Mr. Mallet proceeded to take up the detailed examination of the eastern part of the Sone Valley, and is still engaged in that area. I have already intimated to Mr. Mallet the necessity for greater activity in the field, for looking both to the nature of the work done, and of the country in which he was engaged I felt disappointed that a larger area had not been satisfactorily examined.

Carrying on the geological examination of the Gwalior and adjoining territories, Mr. Hackett was principally engaged near to the Byana hills bordering on Jeypur. The geology of this area has proved intricate and interesting. The sections are unfortunately not good, being cut up by intervening flats of alluvium which conceal the rocks. Rock masses of a peculiar character have been found to intervene between the Vindhyan series, and the metamorphic schists, which may approximately be taken to represent the Lower Vindhyan and the Gwalior series. These are possibly the same rocks as those which stretch away towards Ulwur, and if so, this will give a clue to the geology of the Aravali country. The country around Byana is, as I have already said, rather intricate in structure, and tedious therefore to work out, but I am not satisfied that a larger area might not have been completed during the season. Towards the close of the year, Mr. Hackett resumed his labours in the same or the adjoining country, but has been stopped by a want of maps. He has since been engaged further to the south in tracing out the boundary of the Vindhyan and trappean rocks to the east of the parallel of Neemuch, &c.

Mr. Hughes in the early part of the year was engaged in re-mapping the small coal-fields which occur detached near Kuroun in the district of Beerbhoom, and in revising with better maps, the Kurhurbaree coal-field. It has been difficult to obtain any very satisfactory information regarding this field, for the old pits which were some years since worked by the East Indian Railway Company are now full of water, and there are few other workings in operation. Any description, therefore, now given must be revised when the field is more opened out. At the close of the year, Mr. Hughes was engaged in the examination of the Palamow coal-field in Chota Nagpore. This might, Mr. Hughes thinks, be called in preference the Daltongunj field. It proves very small in area, not more than about 30 square miles, and there appear to be only two seams which can be worked, of which only one could at present be profitably extracted. This varies considerably in thickness. At Rajbera, where it was formerly worked by the Bengal Coal Company, it is eleven feet. It is of moderately good quality The rocks of the field belong entirely to the Talcheer and the Barakar groups. The lithological character of the latter differs considerably from that of the typical rocks in the Ranigunj field, being as it were intermediate between the Barakar and the Ranigunj groups.

Mr. Ball has been carrying on the geological examination of the districts of Singhbhum and adjoining tributary states. He has been able to examine the copper-yielding rocks for a distance of nearly 80 miles; has noted some additional details with reference to the mode of occurrence of gold; and describes cases of excessive local metamorphism of the younger rocks, reducing them to such a crystalline condition as to be entirely undistinguishable lithologically from the old metamorphic rocks. Such cases are deserving of very careful examination.

Mr. Ormsby had, in the early part of the year, examined a considerable area of the metamorphic rocks in Chota Nagpore and Hazareebagh, but was unfortunately obliged to leave for Europe in consequence of ill-health before the close of the season.

Having very frequently had occasion to represent the importance of deputing a special officer of the Survey to the examination of the mines of India, and to the careful collection of statistics regarding the quantity and value of minerals raised and brought to market, I was glad to find that a gentleman, selected for this purpose, had been ordered to join the department at the beginning of the year. Mr. Mark Fryar, thus nominated as Mining Geologist in connection with the Geological Survey of India, joined his appointment in this country on the 1st of May 1868. After a little time in Calcutta, Mr. Fryar was deputed to the Ranigunj coal-field, there to make himself acquainted with the coal-bearing rocks of India, and the method of mining adopted in this, the most valuable, coal-field in India. It was necessary that he should acquire a knowledge of the rocks as locally developed, which would be useful in other localities, and indeed perfectly essential before he could safely take up any enquiry in a new and undeveloped district. Mr. Fryar also, later in the season, visited the Kurhurbaree coal-field, when Mr. Theo. Hughes pointed out to him the several groups and their characteristic lithological characters. Towards the close of the year Mr. Fryar was deputed to the Nerbudda valley, and to pass thence southward by Chindwarra to Nagpore and Chanda, where Government had sanctioned the full and detailed examination by actual sinkings and borings of the extent and character of the coal known to exist there. For this purpose boring rods of best construction and borers have been despatched from England, and the work will be taken in hands at as early a date as possible. Mr. Fryar has submitted brief reports on the coal found at Lameta Ghât, Jubbulpore, and on the workings at the Nerbudda Coal and Iron Co.'s colliery at Mopani. The localities must again be visited by some one knowing the Indian rocks.

I hope that the necessary appliances for boring, &c., which have been sent for, will reach this country before it be too late to do any thing this working season. Once commenced, the investigations will be carried on systematically, so as to ascertain exactly the full extent of area over which the coal beds extend and the thickness and nature of the coal itself. The country is much covered with alluvial deposits, and excepting by actual trials it will be impossible to say what the extent of the coal-fields may be, while the importance of the locality taken in connection with the supply of fuel on the Nagpore branch of the Great Indian Peninsula Railway and for other purposes, cannot be over-estimated.

It has not been found possible, with the reduced number of our staff, during the present season to place any one of the officers of the survey in this part of the country, with a view to trace out the extension of the coal-bearing rocks to the south from Chanda, if they do so extend. It is probable that the further extension will be traced, although the evidence seems tolerably conclusive that there is a continuous diminution in thickness of these rocks as they pass to the south; and it is highly probable that they will be found not to extend much further than they have been already traced. We know that they have entirely disappeared, at about seventy miles in that direction, and steps will be taken at the earliest possible date to have the intermediate country examined. Reports of the occurrence of coal have frequently been circulated, and recently it is stated to be in some quantity near Domagoodium: but these reports have not as yet been confirmed.

When proceeding to the Ranigunj field, I specially directed Mr. Fryar's attention to the very high importance of inducing, if possible, the colliery proprietors to economize the large amount of waste and dust coal which at present is allowed to take fire and burn away to no useful purpose at the pits. The peculiar structure of Indian coal renders the proportion of this waste, produced in hewing, larger than in coal of a more homogeneous and richer character, while the very much greater brittleness of the strings of rich jetty coal as compared with that of the tougher laminæ of earthy matter also adds to the proportion of the better fuel, which is lost in the waste. I urged on Mr. Fryar to induce some of the proprietors to make trial of washing and compressing this waste and dust so as to form bricks or cakes of fuel, and mentioned to him the success which had attended some experiments made by myself, on the use of common rice water as a medium for agglutinating the mass. Several trials were made and many bricks produced from washed waste, and, as I believe, good promise of success was established. The system has not, however, as yet recommended itself to the proprietors; they believe that the expense and cost would not be repaid by the result, and they have therefore not taken any steps to carry the trials further.

In the experiments I had myself made years since, and in those which were made by Mr. Fryar during the past year, no sufficient pressure was available. And in consequence, although the rice-water appeared to act very successfully, there was much too large a quantity of it taken up. The result of this was the comparatively open and uncompressed texture of the bricks, and when put on the fire they smouldered away rather than burnt. The only pressure used was that of a very inferior brick machine, nor was anything like proper attention paid to washing the dust before moulding.

I am quite confident that a very large amount of most valuable fuel could be with profit economized in this field, all, or almost all, of which is at present allowed entirely to go to waste. I do not anticipate that it will ever be profitable, under the peculiar circumstances of Indian fields, to adopt the suggestions thrown out by some who have never seen these fields, of reducing all the coal extracted to fine powder by crushing, then washing, moulding and baking into symmetrical blocks. But I am satisfied that much may be made out of the dust and dead-small coal, now wasted. The peculiar conditions of the field render it compulsory that all this should be brought to bank so that the only expenses to be incurred are in the actual manufacture. It would surely be more profitable to reduce a larger portion of this waste into the state of good useful fuel than to allow it to take fire and burn itself to a heap of ashes.

Mr. Fryar's attention was also given to the utilization of the small coal and dust for the production of coke, and with considerable success.

During the past year, a circular was addressed to the proprietors of collieries from this office, urging on their consideration the vast importance of maintaining proper under-ground plans, pointing out very briefly the advantages to be derived from such. And I was much gratified to find from the replies received from every one of the large proprietors that they not only saw the advantages to be gained, but were determined to secure them. Careful plans are now being made of most of the mines in the Ranigunj field; plans of the workings in the Kurhurbaree field will be commenced as soon as the workings there commence under the East Indian Railway Company, and will be maintained. In the Nerbudda plans are kept. I look upon this as a most gratifying progress for a year or two. The largest coal proprietors in the Ranigunj field have not only engaged a qualified mining surveyor, but they have ordered all their assistants to pass an examination in the use of the surveying compass, &c., and have secured attention to this study by giving an increase of Rs. 50 per month to the salaries of those who may pass. The same Company has also given an excellent example of progress by ordering one of their own servants, and who, by their permission only, is also examiner of steam-ship boilers under the Government of Bengal (Mr. Walker), to proceed each half-year to their works to examine carefully and report upon, in detail, the condition, work, duty, and capabilities of every one of their steam engines; this report to be submitted previously to each half-yearly meeting of the Company.

MADRAS.—In Madras Presidency, Mr. Foote was absent on medical certificate during the greater part of the year. He only returned late in October. The remainder of the party, Mr. C. Oldham and Mr. King, commenced the season's work north of Ghooty, and marching up to Kurnool, surveyed, as they passed along, a sufficient breadth of country outside of the boundary line of the Kuddapah rocks, to ascertain the non-existence of any outliers of those rocks in that neighbourhood, and to obtain a good general idea of the character of that area of metamorphic rocks. It proved to be chiefly an area of granitoid gneiss, with a few trap-dykes, and some runs of fault-breccia; the prevalent directions of these being west-north-west, with variation to north-west, and east-north-east, with a variation to north-east.

From Kurnool, the Surveyors passed across the hills to the east, by the Muntaval pass. Mr. King separated from Mr. Oldham at Doopaud, from which he moved northwards, carrying on his examination in connection with the survey of the previous season. Mr. Oldham proceeded to the Kistna district to join the Superintendent.

Mr. King rejoined Mr. Oldham in the middle of February, and working first through the Vinuconda taluq, they then passed into the Palnad, and carried their geological lines up to the Kistna River. Parts of this country are very difficult of access, wide areas quite uninhabited, without roads and without any means of obtaining needful supplies. Much of the geological structure is also intricate, and the district is at the same time very unhealthy. The temperature during the past year was unusually high in April and May, and repeated attacks of fever prevented the officers of the survey from carrying on their examination with their usual vigour. They continued, however, at work until the beginning of June, when Mr. King was compelled to proceed to station. Mr. Oldham went northwards and crossed the Kistna, hoping to be able to complete a detailed survey of the Juggiapett country. A part of this only could be accomplished, for the early and heavy break of the monsoon compelled him also to leave the field about the middle of June.

During the autumn Mr. Oldham delivered at the Civil Engineering College in Madras a course of lectures on Geology. These were attended, and with marked regularity, by a larger number of the general public than on previous occasions, while the engineering class was also very attentive and interested in the subject.

When I left the neighbourhood of Juggiapett early in the year, as already referred to, I had hoped that there would have been time to accomplish a detailed survey of that small area, taken in connexion with the adjoining country, before the close of the season. As I have just stated, the early and very severe setting in of the monsoon prevented this. I regret this the more, from the reiterated statements which have been made as to the existence of coal in that vicinity. Mr. C. Oldham, in regretting that he was compelled to give up the attempt to finish the work at that time, says—'I was, however, able to trace out the succession of the beds there for a considerable distance, and I had the opportunity of examining with somewhat more detail than we were able to do, during our visit early in the year, the way in which the rocks lie, and to convince myself (in entire accordance with your own conclusions) that, certainly over the part of the area which I was able to survey, in which are some of the localities where coal had been reported, not only does none appear, but that the occurrence of any thing like a workable seam of coal, unseen, is impossible. The rocks are singularly well exposed and their succession very clearly seen. The general succession of rocks seen in the Juggiapett area is, in ascending order, quartzite slate, limestone, schistose slates, and over these upper slates, in the hills to the south, comes apparently another set of quartzites.' The two lower groups, Mr. C. Oldham is inclined to refer to the Kuddapah series of rocks; and the limestone with the slates above it to the newer Kurnool group. There is apparently unconformity between the two series here, as in many other places. The Kurnool rocks cover a large area in the Palnad, and the two limestones with associated shales, are seen separated by quartzite, (the 'Paneum' quartzite of the survey); this is locally of considerable thickness and forms a very well marked bed, but elsewhere it thins out to a couple of feet or even disappears altogether. The lower limestone of the Palnad is apparently identical with that which covers so very large an area near Juggiapett, although the actual continuity of the two still remains to be traced. Much of the limestone would form a very durable and excellent building material, and several of the beds would yield a handsome ornamental marble, being veined in different colours, chiefly buff and pink.

Chipped stone implements were traced up to the Kistna district. On the Muntaval pass, one was extracted from hard solid laterite.

From Bezwara, Mr. C. Oldham visited a small area of sandstone at Tunglamoody, about 14 miles south-south-east of Bezwara. These sandstones there form a rising ground or hillock of no great extent. They are quarried for use in the adjacent country, where many temples have been built of them. No fossils were traceable, but from the general character of the rocks, Mr. Oldham considers them as belonging to the same group as the plant sandstones further to the south, to some of which they bear a great resemblance. Further, while marching back to Madras from Guntoor, he noticed similar sandstones and some porcellanic shales in several places near to Yinkolu, and south of that along the road: and at Razpoody a considerable amount of them is exposed, chiefly a greyish and yellowish shaly sandstone. These beds are quarried to some extent for local building purposes. The great resemblance lithologically of these rocks (shaly sandstones, and porcelain-like shales) to those in the neighbourhood of Sripermatoor, in the Madras district, is striking. Mr. C. Oldham thinks all these belong to the same series, and thus we have, at a distance of 450 miles from where we first found them in the Trichinopoly district, remains of a series of deposits once continuous, and the connection of which is now only indicated by the many detached areas of the same beds, which have been traced by the survey in the South Arcot, North Arcot, Madras, and Nellore districts.

BOMBAY.—The Bombay party of the survey has been during the whole year under the charge of Mr. A. B. Wynne, Mr. Blanford being, during all the time, absent with the Abyssinian Field-force. The party was engaged in the examination of Cutch, of which area about one-half has been very carefully completed. The reported occurrence of coal, said to be in workable quantity, was one reason which demanded a careful investigation of the rocks and their relations. But the principal interest connected with the investigation of Cutch centered in the fossils, which occur there in considerable abundance. Along with others, very well preserved remains of peculiar plants occurred, easily recognizable, and giving a very marked *facies* to the flora of these rocks. This was characterized by the predominance of various forms of Cycadeæ. These same forms of Cycadeæ had been found in abundance in Bengal, at the opposite side of the Indian peninsula, and in many places near to Madras, far to the south. In the Rajmahal Hills no associated beds occur from which the true geological horizon of these plant-bearing rocks could be made out, while in Madras presidency also, although the succession clearly established that these rocks were not younger than the cretaceous formation there developed, there was (equally as in Bengal) no possibility of fixing their lower limit in geological time. In Cutch these plant-bearing beds, on the contrary, were said to occur associated with rocks rich in marine fossils, well preserved, and the geological epoch of which was well marked and readily determinable. But although undoubtedly associated with the marine fossiliferous beds, the mode of this association was still uncertain. Captain Grant, the original describer of the province, left it doubtful; while Mr. W. Blanford, during a cursory visit to part of Cutch, was led to believe that the plant-bearing rocks were actually intercalated with the others. The facts, as resulting from Mr. Wynne's very careful and detailed examination, appear to be that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked *Palæozamiæ* occur are decidedly younger than those containing the truly Jurassic *Ammonites* and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period. These very important results will be illustrated in detail in Mr. Wynne's reports.

Mr. Fedden has been engaged with Mr. Wynne in this careful examination of Cutch, and has more especially devoted himself to the portion of the province occupied by the tertiary rocks.

Very extensive and valuable collections of fossils have been made by this party of the survey, and transmitted to the Museum.

BURMAH.—Mr. W. Theobald, Junr., having returned from absence of leave, resumed the examination of British Burmah towards the close of the year. The time which elapsed up to the end of the year has been too brief to admit of any great progress. The country under examination has been that portion of the Prome district which stretches between the Eastern or Pegu Yoma and the Irrawaddi, and lies to the north of the Toung Raweng stream. This will, when finished, complete the whole of the Prome district east of the Irrawaddi. I confidently hope that we shall now be able to complete the examination of all British Burmah soon. The results at best are unsatisfactory from the absence of any good sections; and any attempt at classification of the rocks can only be of the largest kind. The whole country is too much covered to admit of any great detail.

PUBLICATIONS.—During the year under report, we have commenced the issue at stated intervals of a new series of publications called the "RECORDS OF THE GEOLOGICAL SURVEY OF INDIA." These are printed in smaller type and on thinner paper (for free transmission by post) than the more detailed Memoirs, but of the same size, so that they can on completion of a volume be bound with these. It is contemplated to issue a number every three months, making four numbers or parts in the year. It was impossible, however, to commence the issue until after several months of last year had passed, and therefore, for 1868, only three numbers appeared. In explanation of the object with which this series has been commenced, I may quote here from the brief Prefatory Notice which accompanied the first part. 'This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere, as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge.'

The three numbers issued in 1868 have contained papers on very varied subjects; coal, gold, copper, fossils, and several local descriptive papers, which have proved of much interest to local officers; also lists of all additions to Library, &c., during the year.

I am happy to say this new series of publications, although necessarily issued with very few illustrations, has already attracted much interest, and I think will prove very useful.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA, a very valuable part has been issued, containing a full report on the geology of the lower parts of the Nerbudda and Taptee Valleys by Mr. W. T. Blanford. The delay involved in the preparation of the necessary illustrations for this paper caused it to appear later than I had hoped. In the same part is also a detailed description of the structure and anatomy of the very curious little frogs long known to be found in some thin papery shales near Bombay. To these Professor Owen had in 1847 given the name of *Rana pusilla*. More careful investigation, and more perfect specimens, show that these strange little frogs belonged to the existing genus *Oxyglossus*.

Mr. Blanford's report includes all the country lying between the parts already described by Mr. J. G. Medlicott (see Vol. II, *Memoirs Geol. Survey of India)* and the Gulf of Cambay, and thus completes a geological section right across the peninsula to the neighbourhood of Bombay.

This part completes Volume VI of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

Of the figures and descriptions of Indian fossils, included in the **Palæontologia Indica**, the second half of the description of the Cretaceous Gastropoda was issued in October. This contained four fasciculi, and being ready at that time, I was enabled to issue it in advance, so as to carry the publication up to October of the present year. The danger of loss, the facility of destruction or injury, and the delay in transmission, of the smaller fasciculi, render it preferable to issue the whole series due for a year at once, if this be ready.

The description of the Gastropoda, concluded in these parts, was carried out to the close with the full detail to which I specially alluded in my last report.

Much progress has been made in the preparation of the needful plates for the illustration of the Bivalves, the group which will be published next.

At the request of several local officers we have, during the year, furnished brief geological descriptions of their districts, which they needed for statistical accounts, descriptive reports, &c., &c.

LIBRARY.—During the twelve months of 1868, we have added to our library 1,766 volumes, or parts of volumes, of books. Of this total 508 were presented or received in exchange for the publications of the Geological Survey from Societies and other institutions. We continue to maintain our catalogue of these books up to date, and in the new series of our quarterly publications (THE RECORDS) a complete list is given, in each part, of those received during the preceding three months. It is hoped that this announcement being sent to the several Societies from whom the presentations have been received will suffice as an acknowledgment, and will thus obviate the necessity of separate communications.

We are quite as seriously inconvenienced in our Library arrangements, by the want of sufficient space, as in the Museum. The books are necessarily placed in double rows and often far too crowded in their cases. This renders it impracticable to be as careful of them as might be, and also seriously interferes with facility of consultation or reference. To give fair room for all we would require at least double the number of cases and shelves we have at command.

To this report is appended as usual a list of the Societies and Public Institutions from which the Geological Survey of India has received donations or exchange of publications during the year 1868.

In my last report I stated that the literature of Geology, Mineralogy, Palæontology, &c., had of late years so vastly increased that it was impossible to maintain our library effectively from the small sum annually appropriated to such purposes and I am happy to be able to state that an increase to this sum has since then been sanctioned.

MUSEUM.—Up to the close of the year we had not received all the series of fossils procured during 1867 in Europe, in connection with the purchase of the Klipstein collection. But few now remain to be received, and I hope to be in possession of all at an early date.

During the year, I had the advantage of the aid of Mr. Geoff. Nevill in arranging, preparing, and cataloguing these fossils as opportunity offered for opening and examining them. In many cases, the want of space has rendered it necessary merely to open, examine, check, and pack up again, box after box, as we have not space in which even to arrange, much less exhibit, our collections. Three additional rooms have been given up to the museum, and this will afford a certain amount of relief, when we have been able to procure cases. During the year more than 6,000 specimens have been catalogued.

We have returned to the Central Museum, Madras, the Cretaceous Gastropoda which they had been good enough to lend us for examination and description, and we have added to the list as complete a series of duplicates of this group of fossils as our collections could afford. I think local museums should especially, and in preference to any more general illustrations, seek to render their collections specially rich and illustrative of local Natural History, and my desire has been to place in the Madras Museum the best series of duplicates which could be selected from the very interesting and valuable collections of Trichinopoly fossils made during our geological examination of that district in the Madras Presidency. With a similar object, I also sent to the Museum at Rajamundry as complete a series as our collections would afford of the interesting tertiary fossils found close to that town, carefully named, and with accurate references; so that those interested might have some good data for comparison, if they had the opportunity of adding to these local collections. We have also during the year examined and named for several persons specimens and small collections.

From the officers of the survey working in Cutch, the collections have received very large additions; among which are many good specimens. The other parties of the survey have not been engaged in richly fossiliferous districts. Mr. Medlicott has brought a small series from the Khasia Hills, and a few have been received from Burmah.

METEORITES.—To the noble collection of meteorites in our Museum have been added during 1868 specimens of the fall of Pultusk, 30th January, 1868: of Klein Menow, 7th of October, 1861: of Perth, 17th May, 1830; of Ornans (Doubs), 11th July, 1868; and of Lodran near Mooltan, 17th of October, 1868, being five in all. Of one of these (Klein Menow) our collection contained a minute fragment before, but we have now obtained a very splendid specimen. The others are all new to our series. For the very rare specimen from Perth, I am indebted to the friendly kindness of Mr. Wm. Nevill, Godalming, Surrey, from whom also I procured the Klein Menow specimen. To my good friend M. Jules Marcou, Paris, I owe the specimen of Ornans, while the contribution of that from Pultusk was among the latest communications received from the able Director of the Imperial Mineral Cabinet at Vienna, Dr. M. Hörnes, since deceased. This was only one among a very numerous and long-continued series of friendly communications, in which I have ever experienced the most hearty and graciously rendered support and co-operation from the Austrian Geologists, and from none more warmly than from the greatly regretted Hörnes.

A small map is as usual appended, showing roughly the areas of which the geological examination has been completed, or is now in progress, in connection with the survey.

THOMAS OLDHAM,
Supdt. of Geological Survey of India, and
Director of Geological Museum, Calcutta.

GEOL. SURVEY OFFICE;
CALCUTTA, *March* 1869.

***List of Societies and other Public Institutions, &c., from which Publications have been received in donation or exchange for the Library of the Geological Survey of India during the year* 1868.**

LONDON.—Royal Society.
" Royal Institution.
" Royal Asiatic Society.
" Geological Society.
" Geological Survey of Great Britain and Ireland.
" Royal School of Mines.
" Royal Society of Arts.
" Royal Geographical Society.

DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GLASGOW.—Geological Society.
CORNWALL.—Royal Geological Society.
VIENNA.—Kais. Hof Mineralien Kabinet.
K. K. Geologischen Reichs-Anstalt.
Kais. Akad. der Wissenschaften.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
BERLIN.—Deutschen Geologischen Gesellschaft.
BRESLAU.—Schlesischen Gesellschaft für Vaterland. Kultur.
MUNICH.—Kön. Bayerischen Akad. der Wissensh.
MOSCOW.—Société Impériale des Naturalistes.
SWEDEN.—Bureau de la recherche Géologique.
NORWAY.—Royal University of Christiania.
PARIS.—Comm. des Annales des Mines.
„ Société Géologique de France.
DIJON.—Acad. des Sciences.
CAEN.—Société Linnéenne de Normandie.
BELGIUM.—Academie Royale des Sciences, Bruxelles.
NEUCHATEL.—Société des Sciences Naturellés.
LAUSANNE.—Société Vaudoise des Sciences Naturellés.
ZURICH.—Naturforschenden Gesellschaft.
TURIN.—Royal Academy.
GOETTINGEN.—Königl. Gesellschaft Wissenschaften.
GERMANY.—Leop. Carolino Acad. of Sciences.
COPENHAGEN.—Danish Academy.
PHILADELPHIA.—Franklin Institute.
„ American Philosophical Society.
„ Academy of Natural Sciences.
BOSTON.—Society of Natural History.
AMHERST, MASS.—Museum of Compar. Zoology.
SALEM.—Essex Institute.
WASHINGTON.—Smithsonian Institute.
NEW HAVEN.—Connecticut Acad. of Arts and Sciences.
TORONTO.—Canadian Institute.
VICTORIA.—Geological Survey.
„ Office of Mines.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
BOMBAY.—Branch of Royal Asiatic Society.
ROORKEE.—Thomason College of Civil Engineering.
Governments of India, Madras, Bombay, Bengal, North-Western Provinces, Chief Commrs., Oude, Central Provinces, Burmah.
Great Trigonometrical Survey of India.

NOTE *on* PANGSHURA TECTA, *and two other species of* CHELONIA, *from the newer tertiary deposits of the Nerbudda Valley*, by FERD. STOLICZKA, PH. D., *Palæontologist, Geol. Surv. of India.*

While engaged in the examination of the tertiary (? pleiocene) deposits of the valley of the Nerbudda river in 1858, Mr. W. Theobald, Junior, obtained, among other fossils, a few remains of CHELONIA which are of great interest as throwing light upon the then existing representatives of this reptilian order.

Mr. Theobald described these deposits at some length in a paper "On the tertiary and alluvial deposits of the central portion of the Nerbudda valley" (Memoirs, Geol. Surv., India, Vol. II, p. 279). He distinguishes two groups of beds, an upper and a lower. To both of these a large number of the fossils is common, but Mr. Theobald is inclined to think that those of the upper group may have been, partially at least, derived from the denudation of the lower group. The beds of this lower group are more fossiliferous than the others, but they can only be examined where they are exposed in the banks of the Nerbudda river itself, and in those of a few of the larger tributaries. The same author also gives a list of land and fresh-water shells found in these beds. Many of the species noted are still met with recent, and some appear to be identical with those determined by Prof. Ed. Forbes from the Sevalik strata (see Falconer's Palæont. Mem., Vol. I, p. 389). Of the vertebrate fossils also, several species are common to both the Nerbudda and Sevalik strata. Still some peculiarities in the Bovine and Pachyderm types have been pointed out, which seem to show that the deposits of the Nerbudda valley are younger than those of the Sevalik hills. On this point it is difficult to arrive at any definite conclusion from the examination of the fossils alone. The comparatively larger number of Bovines in the Nerbudda beds, as contrasted with the Pachyderms, the absence of Mastodons, &c., may be due to local causes. And further, the number of fossils as yet known from the Nerbudda is small, while from the Sevaliks, which have been examined more in detail, we have a large number of well determined species. The only question is, whether all the fossils which have been described from the Sevaliks really belong to one series of beds only, or whether they do not in reality represent somewhat distinct horizons (the Nahun series, the upper and lower Sevaliks, &c.) It is certain that no particular attention was paid to these divisions when the earlier collections were made. Much is therefore still left to be worked out, both in the Nerbudda and in the Sub-Himalayan country.

In the present note I shall direct attention only to the Chelonian remains from the Nerbudda valley. Mr. W. Theobald, in his report quoted above, repeatedly states that Chelonian remains occur throughout the lower group, but that they are rare as compared with those of the Mammalia (see pp. 289, 290, 292). Besides these remains of Chelonia I am not aware that any other reptilian remains have been met with in the Nerbudda beds, although Saurians and others most probably existed within that area, as they do now, and as they did already during the time, and in the area, of the Sevalik deposits.

These Chelonian remains are referrible to three species; one, which is sufficiently preserved, has been identified with the recent *Pangshura tecta*, and, of the three other fragments, one appears to belong to a recent *Batagur*, and the other two to a *Trionyx*.

I shall give first a short description of these remains, and then add a few words respecting the conclusions resulting from this examination.

PANGSHURA TECTA, *Bell*, sp., Plate I, Figs. 1, 2.

Emys tectum, Bell, Monog. Testudinarum.
,, *tecta*, Gray, Illustrations of Indian Zoology.
,, *Namadicus*, Theobald, 1860, Mem. Geol. Surv., India, Vol. II, p. 295.
Pangshura tecta, Günther, 1864, Reptiles of India, p. 33.
Emys tecta, Falconer's Pal. Memoirs, 1868, Vol. I, p. 388.

The shell of *Pangshura tecta** has an elongated oval form. The centre of the back is elevated, more or less distinctly carinate, the sides are rather flattened and slope at an angle of about 45°, which increase up to 50° towards both ends. The carapace is anteriorly

* I have adopted here the change in the specific name, *tecta*, as being more in accordance with the general system of nomenclature, although Bell said that Gray had misquoted the name *tecta* instead of *tectum*, the roof of a house, which was intended to express the general form.

about equal to, or a little shorter than, the sternum, and slightly emarginated; posteriorly it is obtusely rounded, and at the marginal shields more or less distinctly serrated.

In the specimen figured on Plate I,—which was discovered by Mr. W. Theobald at Moar Domar in the Nerbudda valley,—the carapace agrees in every respect with that of the recent species, as will be shown by giving the necessary details of its structure. To facilitate a careful comparison, I have also given a drawing of one-half of the dorsal and ventral views of the carapace of a small specimen, procured living in the neighbourhood of Calcutta. These drawings are intended to illustrate not only the epidermoid but also the osseous shields. Proper attention is seldom given to the latter in zoological works, although in palæontological researches they are of greater importance than the former.

The fossil figured is not perfect, the posterior portion of the carapace not having been found; but the rest of the shell is quite sufficiently preserved to admit of careful comparison for specific identification. The general form of this fossil is, as already stated, exactly the same as that of recent specimens.

Epidermoid plates.—The nuchal shield is very small, narrower anteriorly than posteriorly. All the five vertebrals are obtusely carinated in the middle, and the first three become successively more and more elevated at the posterior end. The first vertebral is pentagonal with an obtuse projecting angle in front, slightly emarginated at the sides, narrow and truncate behind. The second vertebral is about the same size as the first, also pentagonal, truncate at both ends, considerably narrower posteriorly than anteriorly, laterally, at one-third of the length from the front edge, widest and angular. The third vertebral is the smallest, but the highest of all, pentagonal, truncate in front, angular at the sides, after which considerably produced posteriorly, becoming gradually narrower and terminating with an obtuse point. The fourth vertebral is bell shaped, very much prolonged, joining the third with an obtuse point, then becoming gradually wider until it reaches about three-fifths of its length, after which it narrows again, terminating with a truncate side, about one-half of the greatest width of the shield. Of the fifth vertebral only the anterior portion is preserved, showing it to be truncate in front and quickly widening posteriorly. The sides were probably obtusely pointed and the posterior termination truncate, broader than the anterior, as in recent specimens. In these the sides of the fifth vertebral are sometimes pointed, sometimes distinctly truncated. Costal or lateral plates are five, all being transversally elongated and of a more or less irregular pentagonal shape. They entirely agree with those of living specimens, as is equally the case with the marginal shields, which are eleven in number on either side. The serration of the posterior marginal shields remains to be properly recorded if better preserved specimens should be discovered, for neither is it distinctly traceable in the figure given by Dr. Murchison in Falconer's Pal. Memoirs.

On the ventral side we have first to notice a pair of small, triangular, posteriorly pointed gular shields. To these follows a pair of larger, subquadrangular post-gulars; then a pair of rather high pectorals, next to which are the abdominals, being the largest, and then the other shields of normal size. The axillaries are comparatively small, posteriorly pointed, the inguinals large anteriorly, on the external side obliquely truncate. The longitudinal ridge which connects each axillary with its corresponding inguinal is very distinct, sharp and slightly longer than in most recent specimens. The plastrum is distinctly concave, probably a little more so than in male specimens, as usually met with about Calcutta.

Osseous plates.—The distribution of the osseous plates, as is well known, does not agree with that of the epidermoid shields. There is a very large nuchal plate and a very small caudal, the latter not being preserved in our specimen. There are ten small vertebrals, the last (the largest) not being seen in the fossil, but the other nine perfectly agree in their relative proportions and in their relations to the epidermoid shield with those of live specimens. The costal shields are eight; the first is the broadest, with reference to the longitudinal diameter of the carapace; all the others are very narrow. The number of marginals is eleven on each side.

On the plastrum we have a pair of subquadrangular gular shields, to which follows a pair of very large pectorals, these four shields enclosing in the middle a single, suboval post-gular; there is besides a pair of very large abdominals and one pair of smaller anals. The axials and inguinals are not separated from the pectorals and abdominals respectively.

No portions of the internal skeleton, as the extremities, &c., have been found preserved.

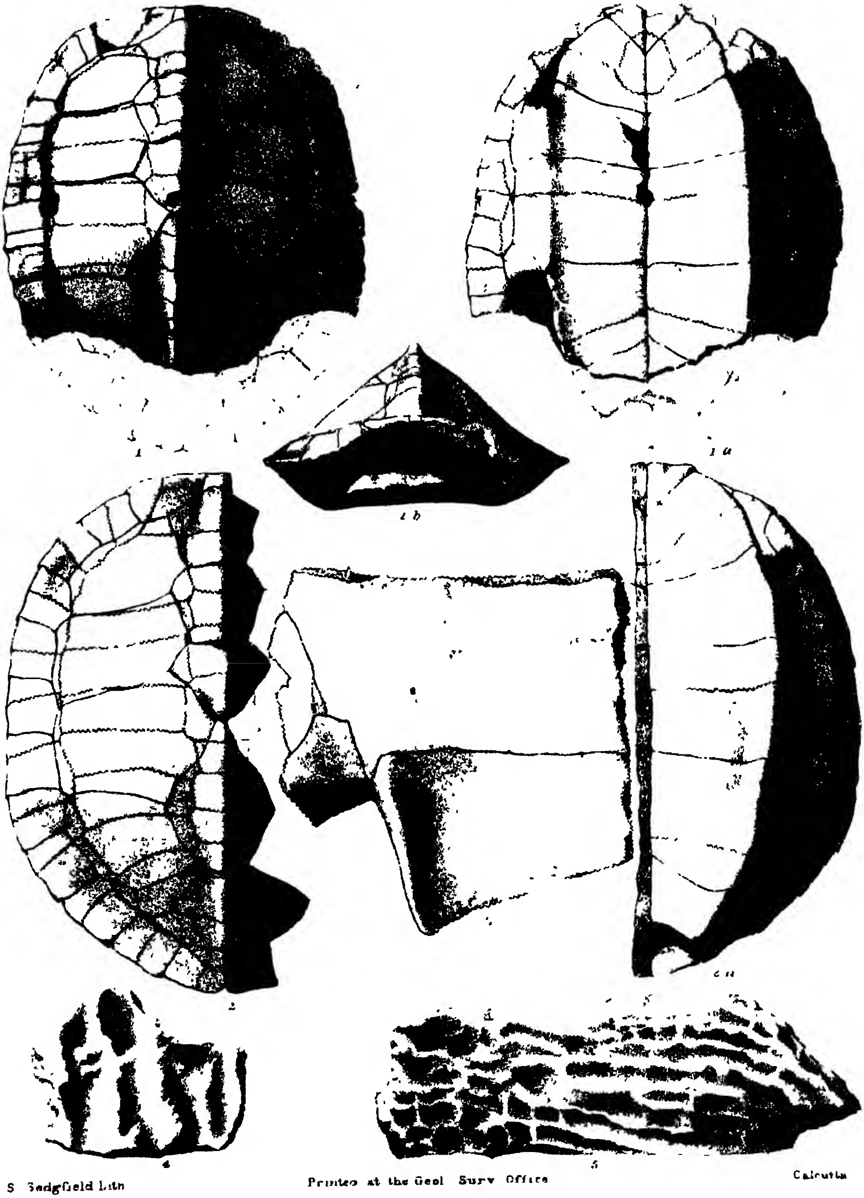
The epidermoid plates in *Pangsh. tecta*, and other allied species, are subject to a great deal of variation, which is especially considerable in the form of the vertebral plates, occasionally so much so that they cease to be of great specific importance. The most variable are the first and the fifth vertebral plates. In the Indian Museum there exists a remarkably large specimen of *Pangsh. tecta* from Cachar. Its first vertebral is pentagonal, the second quadrangular, third rather large, of regular form, fourth very large, bell shaped, the fifth is three-fifths of the length of the former, of almost equal width throughout, truncate in front, sub-angular laterally, and obliquely pointed posteriorly, while, as a rule, it is truncate behind (see fig. 2, pl. 1). There are twelve marginals on each side, instead of eleven, the tenth being divided by a furrow in continuation of the suture which separates the fifth costal from the fifth vertebral. The caudals are very small.

Comparing the epidermoid shields of some of the specimens of *P. tecta* with those of *Pangsh. tentoria*, it is by no means easy to point out any very remarkable distinctions, but the latter species can be always recognised by its broad, depressed back, the sides of the carapace being distinctly convex, and the general form of the shell more elongated. (See Theobald's Catalogue of Reptiles, etc., Jour. Asiat. Soc., Bengal, Extra No. 146, 1868, p. 14). Günther's figure of *Pangsh. tentoria* is by no means characteristic, being almost undistinguishable from that of *P. tecta*.

The costal shields are, on the contrary, much more constant, and they do not appear to vary essentially in allied species and genera. In all the species of *Pangshura* which I have examined they were arranged quite identically.

Mr. Theobald proposed for the specimen here figured the new specific name "*Namadicus*," while Dr. Falconer, in an essay already written in 1844 (see Falconer's Pal. Mem., Vol. I, 1868, p. 382), had identified another specimen found in the Sevalik strata with the recent species. The examination of the Nerbudda specimen has strongly confirmed Dr. Falconer's investigations; that celebrated naturalist summing up his results in the words, "that we are not justified in constituting a difference where we do not find it." Judging from all the solid parts of the carapace, it cannot, I think, be reasonably questioned that the Nerbudda and the Sevalik fossils, as described by Dr. Falconer, are both of the same species, and identical with recent specimens of that species. It might, of course, be said by some naturalists that the fossil specimens may have been, for instance, quite differently coloured, and this would be sufficient to constitute a specific distinction. Such hypotheses cannot, however, be admitted as having any value in pointing out specific distinctions of fossils.

I have no doubt that the specimen from which Dr. Falconer's description was taken is a true *Pangsh. tecta*, but it seems very doubtful that it was the identical specimen figured by Dr. Murchison on Plate 32 in Falconer's Pal. Mem., Vol. I. I have little doubt that this last one is also a *Pangsh. tecta*, but it can scarcely be the identical specimen which Dr. Falconer described. Dr. Murchison (in a note on page 382) pronounces the figured specimen to be the original of Dr. Falconer's description, but when writing the explanation to the plate some of the differences must have struck him, and here he leaves the identity of the specimen doubtful. On page 383 Dr. Falconer says, with reference to the first vertebral, (of the epidermoid coat), "the exact form is not distinctly seen, though it seems to converge less * * *." In the figure two-thirds of the first vertebral are broken off, and no convergence is perceptible. Farther, the author says, "the outline of the fourth scute is not distinguishable in the fossil, and the fifth one is wanting." In Dr. Murchison's figure the fifth shield appears perfectly preserved. With regard to the fourth vertebral scute there is an error in Dr. Murchison's figure. The draughtsman has in place of the outline of the epidermal shield marked the outlines of three osseous plates, and of these he does not seem to have given the outlines quite correctly. The fourth epidermoid vertebral scute extends over three complete osseous vertebrals and an additional one-half, or nearly that, on either end (see pl. I, fig. 2). It is important to point out this distinction, though every one, looking at Dr. Murchison's figure, will readily notice that some mistake of that kind must have occurred. For no *Emys* or *Pangshura* possesses seven scutes in the epidermoid covering, and if intended as a representation of osseous shields, the number is, as I have already stated, too small. In spite of this discrepancy and the somewhat strongly bi-tuberculated second vertebral scute, I can hardly think that the specimen figured by Dr. Murchison belongs to any other species than *Pangsh. tecta*.



S Sedgfield Lith Printed at the Geol Surv Office Calcutta

BATAGUR SP., *conf.* DHONGOKA, *Gray*. Pl. I, Fig. 3.

Günther's Reptiles of India, Ray Soc., 1864, p. 42.

One right abdominal osseous shield has been found in the conglomeratic beds near the village Omeria. This abdominal osseous shield is 108 m.m. long and 94 m.m. broad in the region of the inguinal process. Its form, the flat surface and the outlines of the junction of the abdominal and præ-anal shields, of the inguinal and of the adjoining marginal on the external side, entirely agree with the form of the same shields of the recent *Batagur dhongoka*. Further materials are, however, necessary to show whether this supposed identification be correct.

The species occurs at present throughout India, especially in the larger rivers, and it is found up to the present time in the Nerbudda. Judging from the size of the fossil shield, the specimen to which it belonged must have been about one foot long; specimens much larger than this are met with alive now in India.

TRIONYX SP., *conf.* GANGETICUS, *Cuvier*, Pl. 1, Figs. 4—5.

Günther's Reptiles of India, Ray Soc., 1864, p. 47.

The two fragments which are referrible to the above species consist of the largest portion of the left lower inguinal plate, and a fragment of one of the bony (sternal) processes with broad longitudinal furrows. The rugose surface of the inguinal plate entirely agrees with that of *Trionyx gangeticus*, and this is the only reason which can at present be brought in support of the presumed identification of the fossil with the recent form. The thickness of the plate shows it to have belonged to a large specimen. These two fragments were also met with in the conglomeratic bed near Omeria. *Trionyx gangeticus* is found at the present time living in most of the large Indian rivers, especially in the Ganges and its tributaries.

We have thus up to the present three species of Chelonia upon record from the newer tertiary fluviatile deposits of the Nerbudda valley. These all belong to forms which live in fresh water, and so far agree with Mr. Theobald's conclusions, derived chiefly from a consideration of the shell-fauna, that there are no traces of any estuary or brackish-water deposits. Of these three Chelonia we may accept with the highest probability the identity of *Pangshura tecta* with the existing species, and the great similarity of the other two to existing species is also unquestionable. The Chelonia, probably unnoticed by man, appear to have changed far less in the lapse of time than the Mammalia. The *Pangshura tecta*, and probably two other species (not yet known to occur in the Sevaliks proper), have then continued to exist unaltered, from the time of the *Sivatherium*, *Mastodon*, various *Elephants*, *Hippopotamus*, *Colossochelys* and others, down to the present time. The changes in the conditions of climate, &c., may not have been great, and if the species of reptiles survived these changes man surely would have been able to do the same, had he existed at that early date. That he did so exist, and that he was a contemporary of the *Colossochelys*, as Dr. H. Falconer suggested long since, we have no reason to doubt, although as yet we may not be able to adduce any direct proof of the fact.

EXPLANATION OF PLATE I.

Figs. 1, 1a, 1b; dorsal, ventral and front views—half the natural size—of the carapace of a fossil specimen of *Pangsh. tecta* from newer tertiary conglomeratic beds near the village Moar Domar in the Nerbudda valley.

Figs. 2 & 2a dorsal and ventral views of half the carapace of a recent specimen of the same species; (natural size).

Fig. 3 .. Ventral view of a right abdominal osseous shield of a species closely allied to, or identical with, *Batagur dhongoka*, Gray, from the same beds as Fig. 1; (half of natural size).

Fig. 4 ... Portion of the sternal process of a species closely allied to, or identical with, *Trionyx gangeticus*, from the same beds as the last; (half of natural size).

Fig. 5 .. View of a fragment of the inguinal plate of the same species as the last, and from the same locality; (natural size).

SKETCH OF THE METAMORPHIC ROCKS OF BENGAL, BY H. B. MEDLICOTT, A. B., F. G. S.,

Depy. Supt., Geol. Survey of India.

From the descriptions of the earliest geological observers in India it has been known that large areas are occupied by metamorphic and submetamorphic rocks. It might not appear from its publications that the Geological Survey had given to these formations their due share of attention. But such an inference would be far from correct: coloured maps of large districts might long since have been published, with a general description of the lithology and of the superficial stratigraphical features; and specious analogies might have been drawn with the 'fundamental' rocks of other countries; but any such accounts would be illusive without some definite judgment upon the structure and relations of the several rock-groups. The following notice is a brief abstract of observations made by me during two seasons (1862-63, 1863-64) spent on these rocks, from the watershed of the peninsula near Jubbulpur, in an east-north-east direction, to Monghyr on the Ganges, a direct distance of more than 400 miles. Those who have any knowledge of the difficulties attending the investigation of such rocks will at once understand that my explanations can be only tentative.

The broad promontory round which the Ganges turns at Rajmahal is the termination of a great expanse of gneissic rocks. Here, throughout its eastern extremity, for nearly 100 miles, the gneiss is covered and bounded by the Rajmahal Trap, with its associated plant beds (jurassic), locally underlaid by other members of our Indian Stratified Series; and various outliers, of irregular shape and size, of these latter deposits, comprising our best known coal-fields, are scattered over the area to the west; but from the Rajmahal boundary the gneiss is continuous for 400 miles to the west-south-west to where it passes under the Great Deccan Trap (supra cretaceous) of the Mundla plateau. From the south extremity of the Rajmahal Trap the general boundary of the metamorphic area extends to the south-south-west. Across the middle of the area a straight line might be drawn for more than 150 miles from north to south, continuously on crystalline rocks.

Throughout the greater portion of the northern boundary (the region to which my observations more especially refer), and with few exceptions wherever rock is more exposed, the gneiss is in contact with submetamorphic rocks—slates, schists and quartzites. The exceptions are where, only very locally, the Lower Vindhyans lap on to the gneiss, and where the crystalline rocks themselves extend through and beyond the otherwise regular and continuous run of the schists. This latter case is a most important one; it occurs in about the middle of the region, and is connected with an interruption of nearly 80 miles in the run of the schists, dividing them into two separate areas, and introducing all the doubts and difficulties of identification. In the western area the submetamorphics are continuous along the south side of the Sone valley and into the Nerbudda valley, and are throughout the whole extent bounded on the north by the great Vindhyan range, the strata of which rest totally unconformably upon the schists. In the eastern area, in Behar, the slate series appears in detached groups of hills more or less isolated in the deposits of the Gangetic plain; the principal of these hills are those of Rajgir, Kurrukpur, Ghiddour, Bheowa, and Mahabur. There is perhaps a presumption that the analogous rocks in the two divisions of this great zone are closely related, but many circumstances combine to complicate the question of identification: in the western area the rocks are principally argillaceous, and the metamorphic products of such; while in the east, quartzose deposits largely predominate. Again, this break of continuity is coincident with the eastern extremity of the immense spread of the Vindhyan rocks, and thus, through a general analogy of composition, the possibility was at first suggested (the crystalline rocks not being necessarily all of one period) that the quartzites of Rajgir, &c., might be altered Vindhyans. This supposition may, I think, be quite set aside: the Lower Vindhyans near their eastern limit rest quite unaffected upon the granitics; and the most peculiar and characteristic beds of the Lower Vindhyan series are most extensively developed in this position, yet there are no rocks among the submetamorphics of Rajgir that would even approximately represent them specifically. There is, on the other hand, no inherent difficulty to the general equivalence of the submetamorphic series in the two regions, in the fact of there being much difference of composition at so considerable a distance. It need hardly be stated that only the leading relations of the rocks are to be noticed: no fossils have as yet been discovered in any of them, and no detailed work has as yet been attempted.

The superficial relation of position—a great spread of crystalline, fringed by submetamorphic rocks—is already variously suggestive: the rival leading questions would be—to what extent are the crystallines granitic and intrusive, thus determining the present limit of the schists? or, if the crystallines are in the main gneissic and themselves metamorphic, how far may the present limitation of the submetamorphic series as a fringing deposit be an original feature? No satisfactorily one-sided answer can be given: the facies of the crystalline rocks is emphatically gneissic (metamorphic); there is also ample evidence of granitic intrusion in the rocks of both series; yet, owing to theoretical scruples, and to deficiency of data, the residual phenomena are so numerous that no approximately final judgment can be put forward even as to the main relative ages. It is time, however, that our difficulties should be ventilated. The lie of this great band of slaty rocks, on the south of the Gangetic valley, and followed up, as it is, by the next succeeding deposits of the Vindhyan series, suggests at first sight inferences as to the possible substratum of the great alluvial formation, as to the inducing conditions for the great area of erosion or of depression, and as to possible relations to the rocks on the north of the plains, in the Himalayan region. But, whatever independent interest these large structural features may retain, such speculations as those mentioned are in a great measure negatived by the appearance to the north of the Vindhyans in Bundelkund of a large area of thorough gneissic rocks; and again, in Behar, in the small group of the Barabar hills, well to the north of the Rajgir range, we find very massive gneiss of most ancient aspect.

I must here briefly recall to notice some observations I made in 1856-57 in a neighbouring part of India (published in the 2nd Vol. of our Memoirs) as bearing upon the question before us. To the north-west of the Sone valley, and separated from it by the long eastern prolongation of the Vindhyan formation, there is the large area of crystalline rocks of Bundelkund; it is bounded on three sides by the Vindhyans and on the fourth by the Gangetic plains. Along the south-east border of that area there appears a strip of semimetamorphic rocks—quartzites, limestone* and slaty strata, with contemporaneous trap, rising from beneath the Vindhyans. I described them as the Bijawur formation. They are in many places seen to rest abruptly upon a flatly denuded surface of the gniess of that area. The bottom rocks in this position are peculiar quartzites, often compact and brecciated, and massive cherty limestone; but along portions of the boundary the usual Bijawur strata are underlaid, with at least approximate parallelism, by very non-descript gneissoid strata. The demarcation between these and the true gneiss is, naturally, very obscure; and it was not then possible to work it out; but there are locally some intercalated beds of quartzite-sandstone that effectually betray the stratigraphical affinities of these indeterminate strata to be towards the Bijawur rocks, and totally distinct from the true gneiss, to which they seem in the relation of an ancient superficial covering. We shall see that probable representatives of the Bijawur rocks occur both in the Sone valley and in Behar; and that thus we may at least get a hint as to the relative ages of the gneiss of the two areas.

A large part of the submetamorphic area of the Sone valley is occupied by rocks that would well represent the Bijawurs—ferruginous slaty schist with quartzite, limestone, and much contemporaneous trap. They are much more disturbed than in Bijawur; it is even probable that they are affected by certain granitic intrusions. The uncertainty upon this and upon other unsettled points regarding their relation to the main crystalline area to the south is largely owing to the presence of another older series of slaty rocks in the Sone area. The Bijawur deposits are known to be somewhat fickle, but unless they are so beyond all possible conjecture, there can be little doubt of the existence of this older series. In some of the best sections, notably in that of the Rebund, there is a clear transition from the coarse felspathic gneiss, through well marked stages of crystalline metamorphism, into a series of fine clay-slates, with plenty of intrusive greenstone, but in which none of the characteristic Bijawur rocks can be recognised. Where decided Bijawur rocks come in contact with the gneiss there is no such intimate relation between the two. Now that maps of this ground are available there is some prospect of our being able to unravel these obscure questions.

The hills formed of the submetamorphic rocks in Behar appear generally as precipitous ridges of quartzite, either singly or massed together in groups. Even in the

* The limestone of Dergoan, which I had doubtfully described as an outlier of the Lower Vindhyan limestone, has since been shown by Mr. F. R. Mallet to belong to the Bijawur series.

latter case the inner vallies are so deeply eroded that it is often difficult to get a sight of the softer rocks contiguous with the hard quartzite. The Rajgir group is the most removed from the main crystalline area; the rocks are less altered than elsewhere; and it presents the best chance of discovering the normal order of succession of the strata. It cannot, however, be said that the strata here are less disturbed than elsewhere; although, on the whole, the strike of the ridges and of the rocks is very constant to north-east by east, the state of contortion could not well be aggravated short of presenting a great brecciated agglomeration. There are some sections in which there seem to be several hundred feet of quartzite in regular succession. At some points also the fine slaty schists present a very wide outcrop without any admixture of quartzite. Except very locally at the contact of the two there is no appearance of interstratification. It will presently be seen how essential it is to the geology of this whole region to ascertain the true order of succession of these two bands of strata. Some of my colleagues have considered the quartzite to be the bottom group; the supposition would alleviate some of our difficulties, and there are no doubt cases in which the schist now overlies the quartzite; but a close examination of the ground does not permit me to adopt this view; I consider that there is here but one great band of quartzite normally underlaid by a considerable thickness of argillaceous strata. There is only one spot at which these Rajgir rocks are seen in contact with others: along the whole south-east face of the range (at least at the several points at which I crossed it) nothing is seen immediately external to the quartzites; at about a mile from the base on this side there is one small outcrop of massive granitoid gneiss. On the north-west side the schists are very generally exposed; and at about the middle they form a wide fringe of low hills, on the outer margin of which, near Ghunsura, there is one good contact-section of the schists with a strong mass of granite. The relation is unmistakably one of intrusion; there are small protrusions and ramifying offshoots from the granite into the sedimentary rocks, and enclosing angular fragments of them. The general effect on the schists is very noteworthy: there is little of what is usually considered as hypogene metamorphism; the line of contact is sharply defined, and the schists tend rather to assume a homogeneous, trappoid aspect, than a foliated, quartzose, granitic one; the granite of the intrusions has lost much of its quartz. Elsewhere to the west, at Sapineri, Putturkati near Gya, and Muhair, and in other isolated outcrops, these re-actions are exhibited on a much larger scale; idols and utensils are extensively wrought from the soft serpentinous rock of the converted schists; and some of the granite dykes yield a fine kaolin, the only considerable use made of which is to adulterate lime.

To the south-east of the Rajgir hills the Bheowa range stands on the border of the crystalline area; and further south, across the narrow valley of the Sukri, rises the fine hill-mass of Mahabur, well in among the crystallines, and overlooking all the high land to the south. One cannot resist identifying the great quartzites of these ranges with those of Rajgir; and at Mahabur we again find a thick underlying series of fine schists. There are, however, considerable changes to be taken into account: all the rocks are more metamorphic than those of Rajgir; the quartzites are frequently full of small innate mica; and the schists are fine mica-schists, garnetiferous, and often with much globular felspar, but still the very kind of metamorphic rock that one might expect from the slaty schists of Rajgir; and they are very markedly distinct from any variety commonly associated with the gneiss. Round the base of Mahabur I did not succeed in finding a section showing even an approximate contact with the surrounding rocks; but on the north flank of the Bheowa ridge there is a fair example of what the general relation of the two series in this region may be. At the north end of the Hurkur pass there are several fine domes of granite; they are excellent instances of a form of rock that is of frequent occurrence all over the gneiss area; a more or less faint foliation is generally traceable in it, and it never shows any attempt to throw out dykes; it would seem nevertheless highly probable that it is in some manner intrusive; the partial foliation (as Mr. Scrope has maintained) being due to traction in the viscid mass. The case before us is about the best evidence that could now be given in favor of such intrusion: one of these domes occurs close up to the ridge of quartzite, and the two rocks show distinct re-actions at the contact; the granite has lost its usual coarse porphyritic texture; the quartzite is more than usually charged with mica, and has a steep underlie from the granite; at the lower levels traces of the schists were observed. If the supposition that forces itself so strongly upon our judgment be correct, that these several hill-masses are remains of a once continuous formation of argillaceous, succeeded by quartzose, deposits, there could be no doubt left of the truly intrusive character of these sub-gneissoid granitic masses. On the same supposition the features of these Behar rocks, as thus far described, would fall well into harmony with generally received notions upon the process of hypogene action,—that these southern portions of the formation, being contiguous to the main region of hypogene activity, have undergone general metamorphism; while that portion at a distance from the centre exhibits special and partial intrusion, with a corresponding degree of metamorphism.

I must now attempt to exhibit those rock-features of the district which can scarcely be brought within, or which would seem anomalous in, the partial view that has been represented. The former are encountered in the sub-metamorphic rocks, and the latter in the gneiss, although it seems possible to bring them under one explanation. At about twenty miles to north-east by east, exactly in the run of the Rajgir range, and having the same strike, are the small hills of Sheikhpura. They also are principally formed of quartzites in considerable thickness. Some of these could not be distinguished from those of Rajgir; many beds are tinted red, a feature not noticed in the Rajgir rock; and on the southern ridge there are schists distinctly intercalated with the quartzite. But the fact most irreconcileable with the view taken of the Rajgir series is that these Sheikhpura quartzites are certainly bottom-rocks. Along the whole face of the ridge over the town they are admirably exposed in contact with a coarse granitoid rock of very doubtful aspect. It is so thoroughly decomposed and so massive that one might readily fail to detect its true character. The quartzite, too, is steeply inclined against it, the beds in contact being of abnormal texture, and in a manner amalgamated with the surface of the rotten pseudo-crystalline rock. The section, however, at once reminded me forcibly of those I had seen eight years previously at the base of the Bijawur series in Bundelkund. This conjecture made at Sheikhpura was fully confirmed ten miles further on in the same direction, where some small hills appear on the banks of the Kiul close to the railway station of Luckieserai. The northern hill is formed of a coarse conglomerate, large and small sub-angular pieces of quartzites (I noticed none of crystalline rocks) in a matrix of gneissose schist; the dip is 50° to south. The southern hill, only about 80 yards distant, is principally formed of an amorphous pseudo-granitic rock; but in it also strings of abraded detritus can be detected. On the south side this mass is overlaid by quartzites of precisely the same description and in the same manner as in the section at Sheikhpura. This section at Luckieserai most strikingly ressembles some in Bundelkund, 400 miles to westward; and the rocks are so peculiar that whatever else is doubtful in the Behar region, I am disposed to regard it as fixed that the Luckieserai beds are strictly geological representatives of the Lower (or rather, Infra) Bijawurs. Now, the question is, can these belong to the same formation as the Rajgirs? There are several suppositions possible: I may have mistaken the true order of the rocks of Rajgir, but this I am least inclined to admit; or, the real bottom rocks may not appear anywhere in the Rajgir sections, the junction at Ghunsura having cut through them; or, both may be bottom-rocks in their separate localities—how far are we at liberty to impose any fixed order upon the deposits, especially as the Bijawurs, which are in a manner our standard of comparison, are known to be most changeable on the same apparent horizon. As if to close this last mode of escape, or to push it to the uttermost, there occurs at Bichua, within two miles to the north-east of Luckieserai, a considerable hill, much larger than those just noticed, composed entirely of fine ferruginous schists, exactly like those of Rajgir or of Muhair; it is quite isolated in the alluvium. There still remains to be tried the supposition we found necessary in the Sone Valley—the presence of two distinct series, but more or less resembling each other in general metamorphic condition. To apply this supposition in the Behar region brings us into difficulties with the gneiss of the main crystalline area: in the Sone district the Bijawur representatives would certainly be the *younger* of the two series there present; and in Behar, too, from what has been so far stated, we should start with the same view; but here we find that the series which we have independently assimilated to the Bijawurs identifies itself most closely with at least one common form of the great gneiss of Bengal.

The Kurrukpur hills form the largest of the Behar groups. The general features are very similar to those already noticed; steep ridges of quartzite rising from the low ground on all sides. Schists occur abundantly within the range. The contortion of the strata is excessive, just as in the Rajgirs. Gneiss appears close to the base on the east and south sides; and on the west and north granitic crystallines occur within short distances. The Ghiddour range lies to the south-west of the Kurruckpurs, between them and the Bheowa ridge; here also the general appearance is similar to that of the other principal hill groups.

Upon these general considerations of similarity of structure, position, and to a great extent of composition, one would not hesitate to suppose the rocks of all these eastern groups to belong to the same formation as the Rajgirs &c.; it is the conflicting evidence of the bottom-rocks, as already noticed, that would suggest a doubt—in the best sections I have seen at the base of the Kurruckpur and Ghiddour hills, the rocks near the great quartzites resemble those of Luckieserai. Although it would still be possible that there are two series of equal magnitude, and so closely resembling, yet quite distinct, the presumable unlikelihood of such being the case would quite outweigh all the difficulties to their complete identification; and it is only on the supposition of the sections to which I allude proving deceptive that I would venture to suppose there being any separation at all among these rocks, further than what may exist between the groups described in Bijawur to which I would then consider them parallel. The case I would explain is well exhibited at the east end of the Ghiddour range: for some distance a low flanking ridge follows the curve, and close to the base, of the great cliff of quartzite; it is principally formed of a coarse schist-conglomerate, sub-angular pieces (some are six inches across) of quartzites undistinguishable from those of the cliff, even to the peculiar innate mica; still the rock is thoroughly metamorphic, with the pebbles firmly soldered to the matrix. The underlie of this rock here is 30° to 50° westwards, thus apparently underlying the rocks of the range above. At the south-east angle, however, instead of following the run of the range westwards, it trends away to south and south-east, with very low dips, and completely identifies itself with the similarly arranged gneiss, schist and subordinate quartzite that cover so much of the low ground. I have little doubt in identifying these rocks with those at Luckieserai; and it appears to me more than doubtful that they truly underlie the Ghiddour quartzites. There is ample evidence on record of younger, apparently passing under older, deposits; and without involving the inversion of either. On the strength of their much more advanced type of metamorphism, these gneissic rocks at the base of the Kurruckpur and Ghiddour ranges have been considered altogether more ancient than the rocks of the hills; but if the suggestion now made be confirmed, that order will have to be completely reversed.

The same conjecture occurred to me from an independent point of view in the neighbourhood of Mahabur. Within about a mile of the east end of this ridge, right in the axis of its strike, we find these associated layers of tough mica-schist, hornblende-schist, gneiss, and subordinate quartzite, covering considerable areas at low undulating angles of disturbance. I was quite unable to conceive how such rocks could have been where they are at the time when the great quartzites were so intensely plicated, and the schists below them received their steady cleavage. The foliation of the Mahabur schists is cleavage-foliation; that of those other rocks is strictly lamination-foliation. This mechanical objection is at least as valid as the chemical one to which it is opposed, and which would determine the relative ages by relative metamorphism. But, indeed, there is little to choose between on this score here, for the Mahabur schists are often gneissose, containing much felspar.

In connection with this question of relative ages, it is necessary to notice the structure of the ranges as related to their distribution. Their isolated positions are not simply due to denudation: it is certain that the matter removed from between them at their present common level consisted in great part of crystalline rock. Uniform as is the general strike of the ridges, the termination of the ranges does not present a serrated front; the quartzites of the outer longitudinal ridges are bent round in a sharp regular curve, forming a continuous ridge of equal or greater elevation at the curve, with a precipitous external face, and generally an equally regular converging internal underlie. This feature is more especially well marked on the eastern aspect. In the larger groups there are internal features of the same kind; the contortion presenting a two-fold system of corrugation, one of which (the east-west one) greatly predominates, producing the marked longitudinal outline of the ranges. The cleavage and its foliation in the schists have been observed to follow these same curves. It was partly upon this evidence in the Rajgir group—that one can walk from any one ridge to any other without crossing a band of the schists which appear so freely in the enclosed valleys—that I inferred the supraposition of the quartzites. The drainage of these internal valleys does not take place endways, but by narrow gaps cut through the longitudinal ridges of quartzite. Outside the hills granitic rocks are sometimes seen in front of these abrupt terminations of the quartzite ranges. Thus it would seem as if the existing masses of the sub-metamorphic rocks had occupied areas of locally greater depression at the time of the first great granitic invasion; and that to this we may owe their ultimate preservation as hill ranges. The feature is well exhibited in Mahabur: the axis of the range would strike up a reach of the Sukri, and on each side of the river there is an elongated oval of granitoid rock, as of denuded domes. The characteristic arrangement of the doubtful gneissic rocks is also better shown here than anywhere I could mention: they appear as regular concentric coatings to the granitoid masses. The area on the south is less elevated, and the diverging dips of the covering rocks range from 5° to 20°; on the northern area they are much steeper as if exposed lower down on the sides of the mass they envelope, but the regularity of the encircling ring is unbroken, and of the same description of rock as on the south, but in thicker masses. Upon the usual evidence of regularly alternating stratification of highly contrasting materials, it is not, I presume, to be questioned that these are true detrital accumulations remineralized; and it might, I suppose, be maintained on the strength of some misunderstood process of hypogene intrusive action that they may have underlaid the Rajgir formation; or it might even be said that the stratigraphical features of the Mahabur region suggest such a relation. But from the evidence before us, I confess to a preference for the contrary supposition: it would require that after the great disturbance and metamorphism of the Rajgir series the whole area was denuded to a much greater extent than now, and that upon the surface thus exposed these accumulations took place, probably of some arkose-like materials, very susceptible to mineral reorganization. Such must have been the composition of the bottom-infra-Bijawurs.* In this Behar area, however, there is ample evidence of a later granitic invasion: in the southern tributaries of the Sukri there are fine sections of great granite dykes traversing all the rocks transversely. This granite is very different from that already noticed; it is highly crystalline; in the centre of the dyke the felspar and quartz form a coarse graphic granite, with associated schorl and beautifully plumose mica. The view I have proposed would imply a prodigious relative antiquity for the Rajgir formation.

The views that have now been presented in connection with the submetamorphic series have manifestly very direct bearing upon the rocks of the great gneissic area. Supposing the conjecture regarding the extensive representation of the peculiar infra-Bijawurs to be correct, there would be four principal geological divisions to be discriminated and mapped, exclusive of all later granites, &c. *1st.* There would be the gneissoid granite, which would seem to be largely present, to be distinguished from true metamorphic gneiss. I should despair of settling this point without the extensive application of microscopical analysis of the rocks; indeed it remains to be seen whether even this test would furnish a criterion, whether the crystals of such a rock would not assimilate more to metamorphic than to fully igneous products. *2nd.* It is more than probable that associated with that granite we should find a most ancient gneissic formation long anterior to the metamorphism of the Rajgirs, and possibly equivalent to the gneiss of Bundelkund. *3rd.* We should probably find remnants of the Rajgirs in their gneissose form. On this point there is some information at hand: far within the great crystalline area, near the Grand Trunk Road north of Burhi, there is an inlier of typical Mahabur (Rajgir) schists. If they always remain so characteristic there will be no difficulty in recognising them. Even here they are attended by the encircling ring of variable quartzites, having high converging dips towards the schists, which occupy the lowest ground in the neighbourhood on the banks of the Barrakar. The quartzites form a narrow ridge round them, and would belong to our next division. *4th.* There would be the hypothetical infra-Bijawurs. The establishment of this series would probably relieve our field work of some perpetually outcropping difficulties, especially in the shape of isolated, discontinuous runs of quartzites and breccias. But apart from these more characteristic beds, I could not now assign a lithological criterion for this series generally: as has been seen they even simulate granitic masses. Great irregularity and discontinuity is one of their features; although frequently presenting excessive contortion, as if when caught between two resisting masses, they are generally comparatively little disturbed; and what disturbance they exhibit seems to be largely determined in direction by local circumstances, resulting in great irregularities of dip. In Bundelkund, where they were first detected, these beds seem to have but little extension; but in Bengal they seem to occupy large areas: I have observed rocks of this description in far distant localities of the great gneissic area.

January 1869.

* As a more recent parallel for such kind of deposits, I would refer to the felspathic beds of the lower Vindhyans as exposed in western Behar, to south-west of Kutumbeh.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 2.] 1870 [May.

Geology of Gwalior and vicinity, by Chas. A. Hacket, Esq., Geological Survey of India.

The following observations will be confined to the southern part of the country near to Gwalior, included in Sheet No. 1 of the Gwalior and Central India Topographical Survey, the northern part being covered by the alluvium, which I did not examine very closely.

Physical features.—The southern part of the area is traversed by six ranges of hills, three of these have an east and west and the other three a north-east and south-west direction. Of the three east and west ranges, that to the south, extending from near the town of Par on the west, to the Sindh river on the east, is between 3 and 400 feet above the level of the plain to the south and presents a steep scarp in that direction. The other two are not so high and are less continuous; the northern range, that north of Gwalior, being formed of a line of isolated hills.

The three north-east and south-west ranges are the continuation of ranges extending to the south beyond Sipri. All of them present a steep scarp to the south-east, and incline, at a small angle, in the opposite direction, roughly parallel to the dip of the rocks.

Two series.—The rocks forming the east and west line of hills belong to an entirely different series from those forming the north-east and south-west line; the former being formed of the Gwalior Series and the latter of the Upper Vindhyan.

Unconformity.—These two series are totally unconformable to each other, the former having been immensely denuded before the deposition of the latter. In fact, I shall show presently that the principal physical features of the Gwalior series, *viz.*, the Par scarp and the two valleys included between the three ranges of hills, were in existence previously to the deposition of the Upper Vindhyan series.

Crystalline.—The narrow strip of country south of the Par scarp is occupied by the crystalline rocks. But except on the scarp and a few hillocks in front of it, the rocks are mostly covered by the alluvium. This area is also traversed by numerous large quartz veins; some of these extend for many miles in length, and attain to a height of 2 or 300 feet above the plain. Further south, these quartz veins are more numerous, longer and sometimes upwards of 500 feet high.

Crystalline Rocks.

Par scarp.—As only a small area of these rocks is exposed within our limits, my observations upon them will be very brief. The greater part of the Par scarp is formed of gneiss. Where highest there is only a capping of a few feet of the Par quartzite, the lowest member of the Gwalior series; but in most of the deep bays, which have been worn out of the scarp, and east of Deogurh where the scarp is cut back by the Sindh river, no gneiss is seen, but the quartzite extends down to the level of the plain.

The gneiss in the scarp is in a very decomposed state, and a good deal covered by the debris of the quartzites, &c. The foliation is obscure, but in places it can be traced; the strike appeared to be east-20°-north.

The gneiss most often seen in the scarp is composed of red felspar, quartz, and black mica, frequently the mica is entirely absent, and sometimes steatite is very abundant.

Another variety of the gneiss occurs at the base of the scarp, at the western end, from **Deogurh** to **Ladera**, and also in the hillocks near the latter place. The differences between the two varieties are strongly marked; this second variety is far less decomposed than the former; the hillocks by Ladera are formed of large blocks of it, some as much as 20 feet across. Foliation cannot be traced, and the felspar in it is white. Many sections of the junction between the two varieties are exposed in the scarp, in all of which the boundary between the two is well defined, the particular characters of each being as strongly marked at the junction as at some distance from it.

Quartz veins.—The strike of most of the quartz veins which traverse the gneiss is north 30° to 40° east, but I have met with one or two with a strike of north 10° to 20° west. These veins often run into the Par scarp at a height equal to the height of the scarp. Near the town of Par one of these veins can be traced for some distance through the quartzite; on either side of the vein the quartzite contains the debris of the quartz vein.

The Gwalior Series.

This series of rocks, named after the city of Gwalior, which is built on it, occupies but a small area in this district; the greatest length along the strike of the rocks being about 50 miles and breadth about 15 miles.

The series is composed of a variety of rocks consisting of quartzite, sandstone, limestone. jasper, and contemporaneous trap. The strike of the rocks is east and west, and the dip towards the north seldom at a higher angle than 3°.

I shall divide the series into two groups, viz.,—

The Par Group and the Morar Group

The first, the lower in the series, consists principally of a quartzite sandstone and some shales; the second includes by far the greater thickness of rocks; but in this group, there is no bed sufficiently strongly marked or continuous along the strike to be used for the purpose of sub-dividing the group.

Par quartzite.—The Par quartzite rests directly on the gneiss; and occupies the top of the escarpment extending from a little west of Par east to the Sindh river.

That the quartzite was deposited upon a very irregularly denuded surface of the gneiss can be seen where the quartz veins penetrate the scarp, as at Goojurra. The gneiss on either side of the vein had been denuded considerably below the general level, and on the east side to a lower level than on the west.

In the scarp behind Par one of these quartz veins can be traced nearly a mile through the quartzite. The vein south of the scarp runs about north-20°-east, and at the top along this line the vein is sometimes seen in the quartzite and at others is covered by it For several yards, on either side of this line, the quartzite encloses large pebbles of quartz evidently derived from this vein.

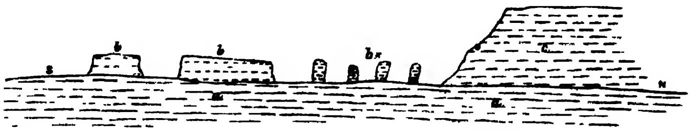
A few inches of the base of the quartzite is conglomeritic, being formed of rolled pebbles about the size of a pea, enclosed in a matrix of red decomposed felspar; above this it becomes very fine in texture, of a greyish color and regularly and thinly bedded.

Thickness.—The thickness of the Par quartzite varies considerably. In some places, as on the top of the scarp behind Par, there are only a few feet of it between the gneiss and the Morar group, but whenever a section of the quartzite is exposed some distance north of the scarp, a far greater thickness is seen. In the Badhano gorge, situated between three and four miles north from the edge of the scarp, there is nearly 150 feet of the quartzites exposed.

Shales.—At the east end, about a mile north of the main scarp, there is a second scarp, about 100 feet high, formed of about 40 feet of green and red earthy, slightly micaceous shales at base, capped by about 60 feet of quartzite. These shales do not appear to the west, but are overlapped by the quartzites in that direction.

At the top of this group there is locally a very peculiar rock. Its greatest thickness is not more than six feet. It is best seen near Bara. East of this it is occasionally met with, but to the west it is not seen in situ. This peculiar bed is very irregularly denuded. Just south of Bara Castle channels are cut through it to the depth of the bed, leaving the rock standing in columns some feet square, and large and irregular patches of it extend for nearly a mile towards the south.

The following is a sketch section of this peculiar bed:—



a - Par quartzite, *bb*[×] — Peculiar bed, *c* —Shales, &c., of Morar group.

The bed presents some variety. At the point *b*,× it is composed of alternations of limestone and silicious bands; the former being softer are more worn, leaving the latter in projecting bands round the columns. The silicious bands weather into a very uneven honeycombed surface. Dr. Stoliczka informs me that they are formed of corals. In the outlying patches south of Bara *bb*, the limestone is entirely absent, and the bed is composed of a compact quartzite, often of a peculiar oolitic structure.

Small patches of this bed are seen resting on the Par quartzite eastwards almost as far as the Sindh river, but the bed is thin, and the limestone absent.

MORAR GROUP.

The rocks of this group consist of argillaceous shales, finely laminated ribboned jasper and hornstone beds, frequently exceedingly ferruginous, but in places the iron is entirely absent. There is also some thickness of limestone having the same ribboned structure, the bands of limestone from $\frac{1}{4}$ to 2 and 3 inches thick alternating with silicious bands varying from a line to an inch in thickness. The silicious bands are often of red jasper.

Trap.—The group includes several spreads of contemporaneous trap, one of them of great thickness and extent.

Thickness.—It is difficult to estimate accurately the thickness of this group, as in parts of the section the beds have a slight roll, but I should say that it must be at least 2,000 feet thick.

The line of junction between the rocks of this and the *Par group* is marked by a slight rise in the ground, seldom more than 30 feet above the top of the Par quartzite.

It is an irregular line, roughly parallel to the Par scarp. At the west end it is only a few yards north of the scarp; but eastwards the distance gradually increases, until opposite Deogurh, there is a distance of nearly five miles between the two.

Badhano.—The only actual junction between the two groups seen along the line is at Badhano. Here resting immediately on the Par quartzite are about 30 feet of white, reddish, and light green micaceous shales.

It is doubtful if these shales exist along the whole line; at all events, there can be only a few feet of them in places; they appear to be overlapped to the south, as the further north the section is situated, the greater the thickness of the shales exposed. Thus, a well situate by the side of the Bombay road, just on the top of the Ghat and about two miles north of the Par scarp, is sunk through the jasper beds nearly on to the top of the Par quartzite. In the bottom of the well, several feet of black carbonaceous shales are exposed, but in a gorge extending north from Simiria into the Par scarp to within a mile of the well, although no actual junction sections are exposed, still there is only a foot or two of the section just above the quartzite covered. No black shales are seen in this section, they may occupy the foot or two covered, but even then, there must be a great reduction in the thickness of the shales between the well and the head of the Simiria gorge less than a mile to the south.

Clay beds.—At Dharoli, the beds resting upon the Par quartzite are white clays with bands of various colours. In this section not only are the black shales overlapped, but some other shales above them: thus in the Sindh river at Bijura the following section is exposed, none of which is represented in the Dharoli section.

Bijura.—The Par quartzite is not seen at base—

30 feet	black carbonaceous, slightly micaceous, finely laminated, shales
2 "	ditto ditto with silicious concretions
0 " 6 inches	red and green shales.
2 " 0 "	ferruginous shales with concretions.
1 " 6 "	red and green shales.
1 " 3 "	shales with silicious concretions.
2 " 0 "	red finely laminated ribboned shales.
4 " 0 "	ditto with silicious concretions

Concretions.—The concretions occur as flattish round balls of flinty chert, sometimes $1\frac{1}{2}$ inches in the shorter, and $2\frac{1}{2}$ inches in the longer diameter; the longer diameter always being parallel to the bedding.

In the Dharoli section the clay beds pass upwards into an irregularly banded rock; the bands of from one-eighth to one-half an inch in thickness and formed of alternate bands of hornstone and silicious brown hæmatite, the bands of hornstone being most frequently the thicker of the two. The clay beds appear to be very local in their occurrence; for in many places, the hornstone beds form the bottom of this group. It seems possible that the clay beds are the hornstone beds locally decomposed. The two are very similar in structure; the hornstone is seen in all stages of decomposition, and the rocks somewhat higher in the section, and equally silicious with the hornstones have certainly decomposed into a similar clay, as, for instance, at the iron mines near Mangor and Santow, &c., where the red and yellow clays can be traced along the strike into the undecomposed red and yellow jaspers.

The thickness of the clay and hornstone beds is about 50 feet The section above them in ascending order is as follows:—

	Feet
Red ribboned jasper with ferruginous bands	150
Ribboned hornstone	50
Red and yellowish, slightly ferruginous, finely laminated, banded shales	50
Silicious ribboned shales	40
Felsites and shales	20
Contemporaneous trap (Choura trap)	70
Felsites and shales	40
Limestone with bands of chert	50
Felsites and shales	60
Contemporaneous trap (Bela trap)	50
Silicious finely laminated ribboned shales, including bands of limestone	300
Ribboned jasper and ferruginous shales	300
Contemporaneous trap (Morar trap)	500
Ribboned jasper and ferruginous shales	50
Limestone with bands of chert and jasper	70
Ribboned jasper, with ferruginous bands	50
Semi-jaspideous ribboned shales	100

Concretions.—Concretionary structure is very common in the lower part of this section, particularly in the jasper-beds. Some of the concretions in these beds are four feet long and four inches thick, but the greater number are about six inches long and $1\frac{1}{2}$ inches thick; the longer axis always parallel to the bedding. The concretions are formed of thin laminæ of red jasper and hæmatite, and are mostly irregularly cracked in the interior and the cracks filled up with quartz crystals. In some of the concretions there are irregular cavities, sometimes 4 inches long and $2\frac{1}{2}$ inches high, lined with quartz crystals. The best sections of these beds can be seen in the gorges north of Simiria, where vertical cliffs of them more than 100 feet high are exposed. The beds of this part of the section are locally worked for iron. A description of the mines will be given presently.

Felsites.—The felsites occur above and below the Choura, Bela, and Puniar traps, as well as under the outlying hillock of trap near Fasoulee. They are mostly thin and regularly bedded, and in this respect resemble the silicious shales, with which they alternate.

The most common variety of the felsites is a cream coloured felspathic matrix, in which are imbedded innumerable dark coloured crystals, probably of augite Another variety consists of alternate irregular, thin light-cream, and dark-green, coloured layers, probably of felspar and hornblende.

The following is an analysis of one of the felsites by Mr. Tween:—

Silica	60·50
Alumina with a little iron	24·51
Lime	2·08
Magnesia	1·32
Potash	9·16
Soda	4·51
Total	102·08

Mr. Medlicott, who has examined a portion of this area, found in the nuddy south of Raipoor some spherical hollow lumps imbedded in the felsites, which he describes as "volcanic (?) bombs, spherical hollow lumps of coarse trappean matter, imbedded numerously like great drops in one of the fine compact intertrappean beds a few feet over the Choura trap flow in section south of Raipoor."

It is difficult to arrive at any conclusion as to the origin of these beds; but from their association with the traps, their general appearance, and composition, it seems probable that they are trappean ash-beds.

Limestone.—The limestones are very uncertain in the section. Of the two limestones exposed in the Dharoli section, the lower, that between the Choura and Bela traps, is covered by the alluvium both in the east and west of the line of section. The upper is very discontinuous along the strike; at some places there is a considerable thickness of it, while in others it is entirely absent.

Uncertain occurrence of limestone.—The best instances of the uncertain occurrence of the limestone are at Bhandaoli, Siharo, and Dangora.

At Bhandaoli the hill is about 150 feet high, in which, in ascending order, the following section is exposed:—

	Feet
Silicious shales	15
Calcareous shales with bands of limestone	20
Limestone	100
Silicious jasper-shales	20

The beds are nearly horizontal; only a few hundred yards further to the east there is no limestone in the section. On the west side, under the castle, the limestone is replaced by ochreous clay beds, in which are a few thin bands of limestone. A short distance further west, the only limestone in the section is in the calcareous shales at the base of the hill.

Siharo.—About a mile east of Siharo and north of Ootilla there is a hill of limestone nearly detached from the main range. The hill is about 100 feet high. On the south side, on the top, there are about 70 feet of limestone; under this about 20 or 30 feet of calcareous shales with bands of limestone and at base silicious shales. In the main range not 50 yards distant there is not a trace of limestone.

Dangora.—Another instance of the uncertain occurrence of the limestone is at Dangora. Here there are about 50 feet of limestone seen in section. It continues round the north side of the hill, but at a short distance to north-east the limestone becomes more earthy until it passes into the ochreous clays. East of Dangora, the limestone continues for a short distance towards Fasoulee, but at that place none is seen in the section.

I might mention many other cases of the sudden disappearance of the limestone, but I think the above sufficient. The rock that replaces the limestone in the section is always the ochreous clay beds. The limestone and the accompanying rocks are as nearly as possible horizontal, so that the sudden disappearance of the former cannot be accounted for by dip. The beds above and below the limestone being identical with those above and below the ochreous clay beds prove that the limestones are not faulted out of sight.

TRAP.

There are at least four separate spreads of trap. I shall name these the "Morar trap," the "Barai trap," the "Choura," and the "Bela trap;" there is also a large spread of trap west of Puniar; this, I think, is a disconnected part of the Barai trap.

Besides these great spreads, several smaller patches occur, as at Kote ki Serai, Malipoora, Singpoora, Baroori, and Fasonlee. It is probable that some, if not all, of these patches are parts of the four great spreads, although the connection cannot be traced, as these parts of the section are a good deal covered by the alluvium.

Morar trap.—The Morar trap is by far the most important from its greater thickness and extension along the strike. A map would scarcely convey a correct idea of its great extent and thickness; as to the eastwards the trap is only seen at the base of the broken northern range and in the isolated hills dotting the Morar plain; but there can be no doubt, these isolated patches, and the trap under the hills round Gwalior, form part of one great spread, extending from Bitholi on the west to Jhankri on the east, a distance of about 30 miles. The western end of the Morar trap is covered by the Kymore sandstone, and the eastern by the alluvium. There does not appear to be any thinning out at either end, for at Bitholi and Jhankri there is as great a thickness as anywhere along the line. About four miles west of Bitholi, in a gorge near Malipoora, the Kymore sandstone is removed and a considerable thickness of trap is exposed. This is just in the line of the strike of the Morar trap and most probably is a continuation of it.

Thickness.—The thickness of this trap must be considerable, although it is difficult to estimate it accurately. The breadth of the spread, at right angles to the strike, is at the western end upwards of three miles. The rocks immediately above and below the trap dip at an angle of 2°, and if the trap has the same dip, it must be upwards of 500 feet thick. But as there may be an alteration in dip between the northern and southern edges, this estimate is possibly excessive. At all events, there are vertical sections exposed in Gwalior fort hill, and some of the hills to the west, showing nearly 200 feet of trap, and some of the hills on the Morar plain, as at Dhaneli, Atarsoo, and Karwas, are nearly 100 feet high and are formed entirely of trap.

Barai trap.—The Barai trap occurs on the south side of Barai hill. It extends to the east nearly as far as Tigara, where it is covered by the alluvium, and on the west for a mile, and is then covered by the Kymore sandstone. There is about 50 feet of this trap exposed in the Barai hill. The small patches of trap, which crop out from under the Kymore sandstone, south-west of Barai, are obviously parts of this spread. The reason of its occurring in detached patches is, that the trap was largely denuded before the deposition of the Vindhyans, and that now, the Kymore sandstone rests sometimes on the trap and at others on the rocks below.

Puniar.—The trap at Puniar is about 1½ miles south of the southern edge of the Barai trap, and of which, although the continuation cannot now be traced, it probably once formed a part. The traps are of about an equal thickness, and the beds above and below them are very similar.

Choura trap.—The Choura trap is about 70 feet thick, and extends continuously from Naigaon, just east of the trunk road, to Choura. East of this, it is covered by the alluvium, but its continuation can be traced some distance further east, as small hillocks of trap are of frequent occurrence in that direction. It is probable that the trap seen in the stream north of Barori is a continuation of this spread, as the limestone on the top of it is very similar to that over the Choura trap.

Its continuation westwards can also be traced, for in the nuddy south of Raipoor, about two miles west of Naigaon, a small patch of trap is exposed, which is probably a part of this spread.

Bela Trap.—The Bela trap is about 150 feet higher in the section than the Choura. It is covered by the alluvium at both the east and west ends, but to the eastwards, there are many outcrops of trap along this line, the farthest of which is at Kote ki Serai, about six miles distant; these all doubtless belong to this spread.

At the northern end of this spread, in the nuddy near the trunk road, north-west of Bela, the trap has the appearance of having broken through the strata and overflowed the rocks to the south. For a distance of about 20 yards, the nearly horizontal shales, upon which, immediately to the south, the trap rests, are seen in actual contact with the vertical trap for a depth of about six feet. East of this section the trap is covered by the alluvium, but to the west it is regularly interbedded with the shales.

Raipoor.—In the nuddy near Raipoor a similar apparent case of intrusion is seen, but here unconnected with any overflowing trap.

The variety of trap forming the different spreads is diorite. It is mostly largely crystalline, the separate crystals of hornblende and felspar being visible to the naked eye. On the top of the Morar trap near Beipoor magnetic iron is very abundant in the trap, but with this exception there is little variety in the trap of the different spreads.

The Vindhyan Series.

Already described.—The western part of our area is occupied by the rocks of the Upper Vindhyan series. This formation, including that portion of it here represented, has already been reported upon by Mr. Mallet, (Mem. Geol. Surv., India, Vol. VII., Pt. 1).

Relation to Gwalior.—I shall therefore confine my remarks to its relation to the Gwalior, and, principally, to showing the extensive denudation of the latter previously to the deposition of the former. Only the two lower groups of the Upper Vindhyans, *viz.*, the *Kymore* and *Rewah*, are here represented; they form three parallel ranges, extending from the south in a north and south direction, but north of the Par scarp they trend to the north-east. The most easterly range is formed of the Kymore conglomerate and sandstone; the next–a few miles to the west–of the shales and sandstone of the Lower Rewahs, and the third–still farther west–of the shales and sandstone of the Upper Rewahs.

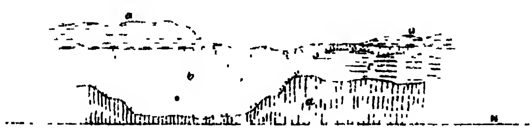
Outliers.—There are also many outliers of the Kymore group resting upon the Gwaliors; one of the largest of these is the Gwalior fort hill, the upper half of which is formed of the Kymore rocks.

Unconformity.—The Kymore cross the whole of the Gwalior section, and along the line of junction numerous sections of the unconformity of the two series are exposed.

Kymore conglomerate.—Further evidence of the unconformity is shown by the Kymore conglomerate, which is formed, almost entirely, where it crosses the Gwaliors, of angular and slightly rolled pebbles of red jasper obviously derived from these.

Doorsari.—But the most interesting sections of the junction of the two series occur in the two gorges near Doorsari at Ladera and near Bhastori. These sections not only show the extensive denudation of the Gwaliors, but also that their present physical features, as, for instance, the Par scarp and the two parallel valleys, existed before the deposition of the Vindhyans.

The Doorsari gorge is situated at the western end of the Par scarp about a mile beyond the western limits of the map. South of the Par scarp the Kymores rest directly on the gneiss and form a scarp running nearly north and south. The section is at the point of contact with the north and south scarp and the Par east and west scarp. The two scarps are each about 200 feet high. The Par scarp is formed of about 150 feet of gneiss capped by 50 feet of Par quartzite. The Kymore scarp a few hundred yards from the contact has about the same thickness of gneiss at base, but capped by the Kymore conglomerate and sandstone. At this point, the conglomerate is only a few feet thick; north of this, the top of the gneiss falls rapidly to nearly the level of the plain, and its place in the scarp is filled by the Kymore conglomerate. At the point of contact of the two scarps, there cannot be less than a hundred feet of the conglomerate resting against the steep Par scarp. At the top of the Par scarp, the conglomerate is only represented by a few pebbles, but it gradually thickens on the low ground to the north.



Junction of the Vindhyan and Par scarps near Doorsari. *a*—Kymore sandstone; *b*—Kymore conglomerate. - Par sandstone. *d*—Gneiss.

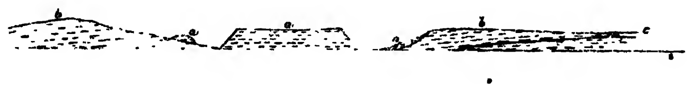
The second gorge occurs a short distance east of the above. On the west side, a similar section to that just described is exposed. The gneiss falls to nearly the level of the plain, and the **K y m o r e** conglomerate increases proportionally in thickness, until, immediately south of the **P a r** scarp, it is nearly a hundred feet thick.

In fact, the ground between the gorges, nearly half a mile, is occupied by a large outlier of the Kymores, at the southern end of which (about a mile from the **P a r** scarp), the conglomerate is only a foot or so thick, but at the northern, there is a hundred feet of it abutting at base against the steep cliff of gneiss, and at the top against the edges of the horizontal Par quartzite, which at the top of the scarp it covers.

Ladera.—The next case proving the existence of the **P a r** scarp previous to the Vindhyan epoch is near **L a d e r a**. It is situated just south of the **P a r** scarp, about 24 miles west of the **D o o r s a r i** gorge. Here the Kymores are seen at the level of the plain, and abutting against the scarp of gneiss and Par quartzite. It is also seen on the top of the scarp. The gorge in the scarp, just west of the narrow spit of sandstone, is also partially filled up with the Kymore sandstone. The bottom and west side of the gorge are of nearly horizontal Par quartzite, but the east side is formed of the Kymore sandstone.

Western extension of Par scarp.—There is also some evidence that the Par scarp extended west of the **D o o r s a r i** gorge, for at **S i r s a**, about three miles west, there is an outcrop of the **P a r** quartzite, and the Kymore sandstone is seen at a lower level immediately to the south of it.

Outlier of Vindhyans at Bastari.—At **B a s t a r i** there is a large outlier of the Kymores, stretching nearly across the southern valley. The hill is upwards of 100 feet high, composed of massive irregularly bedded horizontal sandstone. The base of the hill is covered by debris, so that the Kymore conglomerate is not exposed. Patches of the sandstone rest, unconformably, on the ridges of the Gwaliors, both north and south of the valley. On the south side many of the steep lateral gorges running into the main valley are partially filled up with the Kymore sandstone and conglomerate. It is obvious that the southern valley and the lateral gorges must have been worn out before the Vindhyan epoch, as no amount of faulting could have brought the sandstone into these gorges.



Section near **B a s t a r i**. *a*—Kymore sandstone, *b*—Jasper beds of the Gwalior series; *c*—Par sandstone.

Small outliers.—There are many other smaller outliers of the Kymore, particularly near **J a r g a** and **S o h n s a**. They mostly occupy the low ground, partially filling up gorges, or resting upon the sides of the hills of the Gwaliors, in all cases showing the extensive denudation of the latter previous to the deposition of the Kymores.

The question of the age of the Vindhyan series has already been discussed by Mr. Mallet in his report (Mem. Geol. Surv., India, Vol. VII, Pt. 1).

Gwaliors.—The unconformity of the Gwalior series in our area to the gneiss on which they rest, as well as to the covering Vindhyans, is so great, that no conclusion can be drawn as to the exact place of the Gwalior series in the Indian series.

Hindown.—The only other place where the Gwalior series has been identified to a certainty is near **H i n d o w n**, about 60 miles north-west of Gwalior. The Gwaliors there form a ridge about ten miles long, extending in a south-west and north-east direction. The beds are thrown up at a high angle, seldom dipping less than 60° in a north-westerly direction. Only a few hundred feet of section is exposed. The ridge is entirely surrounded by the alluvium, and thus isolated from the other rocks of the neighbourhood

Upper Vindhyans.—The rocks nearest to the Gwalior ridge are the Upper Vindhyans, the upper group of which, the Bundairs, form a high scarp running nearly parallel to the ridge. The Bundairs are for the most part nearly horizontal, but sometimes at their north-western limit dip at a high angle towards the south-east. There are two other broken ridges in front, north-west of the Bundair scarp, dipping at a high angle to the south-east, probably formed of the lower groups of the Upper Vindhyans, *viz.*, the Rewah and Kymore. The nature of the junction between the Vindhyans and the Gwaliors is obscured by the alluvium.

Byana hills.—A few miles north-west of the Gwalior ridge, and roughly parallel to it, is another line of hills extending from Byana in a south-westerly direction.

Quartzite series.—These hills are formed of a series of rocks not yet described, which we have provisionally called the 'quartzite series.' It consists of an immense thickness of quartzite sandstone, shales and conglomerate. The lowest group includes numerous spreads of contemporaneous trap.

The quartzite series is most probably more recent than the Gwalior and older than the Vindhyan, for the conglomerate of the middle group (Dumduma) of the quartzite series contains pebbles of ribboned jasper, &c., almost certainly derived from the Gwalior series; and some distance south-west of Hindown, near Kerowlie, the Upper Vindhyans rest unconformably upon the lowest group of the quartzite series.

Lower Vindhyans.—Lithologically, the Lower Vindhyans of Bundlekund have some resemblance to the Gwaliors, particularly to the silicious shales of the middle range of our area, but the ribboned jaspers, so characteristic of the Gwalior series, are entirely absent.

It is highly improbable that the Lower Vindhyans and the Gwaliors are synchronous deposits, for no unconformity beyond overlap has been detected between the Upper and Lower Vindhyans in Bundlekund, and yet the lowest member of the Upper Vindhyans, the Kymore conglomerate, is composed largely of pebbles of red jasper, almost certainly derived from the Gwalior series. Again, in the Sone valley, a considerable thickness of ribboned jasper occurs, identical in appearance with the jasper of the Gwaliors, and which series it probably there represents. The Lower Vindhyans rest unconformably upon these jasper beds.

Bijawars.—The Bijawar series and the Gwalior have many points in common; but still the characteristic jasper beds of the latter are not represented in the former. The relation of these two series to each other has therefore yet to be determined.

LATERITE.

There are two patches of laterite in our area; one at Raipoor hill, of which it forms the peak, the highest ground of the district: the second occurs on the Kymore sandstone, about two miles to the north-west. Both these patches are small in extent and are about 60 feet in thickness. The beds composing these hills are exactly similar to each other, and to the great spread of laterite of Central India--purple clay with bands of brown hæmatite at base, capped by the hard porous rock-laterite, and no doubt, these two hills are outliers of the Central India spread, which has been traced as far as Sipri, about 60 miles south of the Raipoor hill.

ECONOMIC GEOLOGY.

Upper Vindhyans.—Mr. Mallet has already described the resources of the Vindhyans in his report on them; in this district the sandstone, both of the Kymore and Lower Rewah, is largely quarried for building stone. The new barracks on the top of the Gwalior Fort hill are built of the Kymore sandstone, quarried from the top of the hill.

Iron.—The principal production of the Gwalior series is iron. Formerly, the workings for iron were far more extensive than now, judging from the large excavations to be met with. The peak of Par hill is completely burrowed by the old workings and a large portion of the hill removed. Similar extensive excavations occur at Mangor and other places. The reason that the workings are not so extensive now as formerly is, not that the iron is exhausted, but that the wood to smelt it is used up, all the hills for many miles round Gwalior being almost entirely bare of any tree or jungle, the ore has now to be taken a long distance to the furnaces.

Par Hill.—The principal iron mines are situated at Par hill, Mangor, and Santow. Nearly all the workings are confined to the lower part of the Morar group, about 100 feet above the Par quartzite. That on Par hill, not now worked, occurs in an outlier of the Morar group, forming a peak rising to the height of about 60 feet above the level of the edge of the scarp. The lower part of the peak is composed of white clay beds with very regular variously coloured bands. The beds of the upper part of the peak are highly ferruginous, the iron occurring in thin laminæ in the variegated clays. It is from these beds that the iron is extracted.

Mangor.—The Mangor mines, about three miles north-north-east of Par hill. These workings are confined to a narrow valley running north and south and nearly half a mile long. On the east side they are bounded by a vertical cliff, the workings extend some 200 yards west of this, but the greater part are close under, or only a few feet west of the cliff. The richest seams are worked by small shafts some 30 or 40 feet deep; but on the west side of the valley iron is quarried from the sides of the low hills. The section in the shafts is very similar to that on Par hill, and the iron occurs in similar fine laminæ in the clays.

In the quarries, on the high ground, on the west side of the valley, the iron is extracted from beds above those on Par hill. These beds, although greatly decomposed, resemble the lower beds of the Morar group; the structure is the same, and they enclose concretions similar to those which occur in the Morar group; but here the jasper and flint, &c., forming the concretions are decomposed into red and white ochreous clays. Both east and west of this valley, the clay beds pass into the undecomposed beds of the Morar group.

Santow.—The workings at Santow are also confined to a narrow space. They are bounded on the north by a large quartz vein, and the principal workings are close to this. The richest beds are reached by small shafts about 50 to 60 feet deep, from which small galleries are extended.

The beds from which the iron is extracted are the same as those worked at Mangor and Par; they are in a similar decomposed state, and pass both to the east and west into the jasper and hornstones of the series.

Smaller mines.—Between Mangor and Santow, on the high ground, there are several workings, but most of them small; there is one place, however, near the curious old tree marked on map, where extensive excavations have been made.

All these workings are on the same horizon as those of Par, Mangor, &c., and the iron is extracted from similar clay beds, which pass into the undecomposed jasper and hornstone rocks in all directions.

The strata in all these mines are locally much contorted. In places there are vertical narrow strips of the undecomposed rocks, running through the clay beds in all directions. These strips are generally from three to six feet wide, and stand up like a wall, sometimes ten feet high. They are mostly formed of thin laminæ of iron, and show sharp contortions, even in their small breadth. They are even harder and more silicious than the unaltered rocks on this horizon, as if the silica from the decomposed beds through which they pass had been secreted in these strips. Iron is not more abundant in the parts worked than in a great part of the series, both on the same horizon and in other parts of the section.

The laminæ of iron are as thick and numerous in the hornstone and jasper beds as in the clay beds derived from them. Again, in the very highest part of the section, above the Morar trap near Kharia, the iron is quite as, if not more, abundant. The reason, that the places worked were selected, was on account of the local decomposition and softening of the rocks containing the iron.

The miners told me that they sold the ore at the pits mouth at the rate of between 60 and 70 maunds for the rupee.

Limestone.—The limestone is quarried and burned, but not on an extensive scale, as the natives appear to prefer the kunkur to be found in the alluvium just west of Gwalior.

Black shales.—Some small excavations were made in the black shales in the bottom of the well by the side of the trunk road west of Puniar, in the hopes of their leading to coal, but, of course, without success; the shales containing only a trace of carbonaceous matter.

NOTE ON THE SLATES AT CHITÉLÍ, KUMAON, by THEO. W. H. HUGHES, F G. S., Geological Survey of India.

Whilst at the hill sanatorium of Almora during the late recess season, I was requested, in a letter addressed to me in September last by Colonel Hodgson, R. E., the Secretary to Government, North-Western Provinces, Public Works Department, to express an opinion, after visiting the spot, as tothe suitability of some slate for roofing purposes, which was known to occur near a village called Chitélí, distant only a few miles from Dwara Hát, one of the well known camping localities betwéen Nainí Tál and Masúri.

Slate required for roofing.—The question to decide was one of importance, for, if the slate were pronounced suitable, it was intended to use it extehsively for roofing the military buildings that were to be constructed at the new station of Raníkhét; it having been estimated by Captain Birney, R. E., the Executive Engineer in charge of Raníkhét, that after taking into consideration the cost of extraction and carriage, the employment of slate would be much cheaper than the corrugated iron in general use for roofing at most of the hill stations.

The following short paper sets forth the views which I entertain regarding both the quality of the slate and the quantity of it available. It would have been impossible, however, for me to have arrived at a satisfactory and reliable conclusion on the first of these points had I not received considerable and courteous assistance from Captain Birney.

Colonel Hodgson's letter reached me on the 17th September, but I did not proceed to Chitélí until the 9th October owing to the lateness of the rains and the reported unhealthiness of the spot.

Position.—The slate occurs in a spur of the hills overlooking a gorge, near the mouth of which the village of Chitélí is built.

In this spur an experimental quarry was opened out, but when I visited it, although efforts had been made to clear away the debris that obscured the section, the extraordinary continuance of the rains prevented the men at the quarry from working as rapidly as they otherwise would have done; and not more than 30 to 40 feet of rocks below the surface were exposed.

The slates dip at high angles; and, as may be presumed, there are different bands varying in their comparative goodness. None of the slates are cleaved in a definite manner, but a few do exhibit this structure in an incipient stage.

Before proceeding to purely economic matters, it may be useful to give, for the information of those who take some interest in geology, a generalised section of the Himalayas, in order to show roughly the horizon which the slate-rocks of Chitélí occupy.

Geological Section.—Commencing at Kálídúngí at the base of the hills, and carrying the section beyond the British frontier through the Milam pass, the rocks occur in the following order of succession:—

A.—Sedimentary rocks. Principally sandstones, shales, and limestones. A few carbonaceous beds occur. Seen on the road from Kálídúngí to Nainí Tál.

B.—Metamorphic rocks. Schists, quartzites; different varieties of gneiss; slates and greenstones. Seen at Nainí Tál, and from thence to Múnshíárí.

C.—Gneiss, with numerous granite veins. Seen between Múnshíárí and the upper Botíá villages of Búrfú and Milam.

D.—Sedimentary rocks,* corresponding to the older, secondary, and newer rocks of European classification. Seen between Milam and the Sutlej river.

The Chitélí slate forms a horizon in the class of rocks under the heading B,—the same class in which the greater portion of the mineral wealth of the Himalayas is contained.

The general quality of the Chitélí slate bears favorable comparison with other Indian specimens; but it is below the standard of typical Welsh slate.

Quality.—It differs from the latter in splitting along the planes of lamination, instead of the planes of cleavage. It is coarser in texture: more silicious (sandy), heavier, and has a duller ring on being struck. Assuming the value of typical Welsh slate as 10, the general value of the Chitélí slate would not be more than 6. There are, however,

* From this band come the *Ammonites* (Salígrám) and the *Belemnites* (Chúchí pathar), which those who cross the snows bring back with them as mementos of their travails and their travels.

some slates,—those occurring about 40 feet below the slates that crop out at the top edge of the spur above the quarry,—which are of somewhat higher value, being closer grained, possessing very even planes of lamination and splitting into thin slabs. These slates form a distinct band, their colour being darker than that of those above them.

In recommending which slates should be utilised, I would certainly say the lower ones; the upper slates being altogether coarser and containing some iron galls.

I am sorry that I possessed no means of testing the absorbing power of the specimens which I brought away with me from the quarry. But Captain Birney assures me that he has carried on experiments during the past twelve months to prove the porosity of the slate, and that the results have been satisfactory. Captain Birney, to further test the slate, had exposed several slabs to the action of the weather. All, with the exception of one which had cracked, were perfectly sound when I examined them. The cracking of one slab I look upon as a matter of little moment as affecting the quality of the slate, for all the specimens had been procured from near the surface; and I believe that this cracking will not occur when the slates are quarried from a lower depth.

Supply.—With regard to the question of supply there need be no fear. If the spur of the hill be opened out on both sides, there will be a store of slate more than ample to meet all the demands of the barracks at Raníkhét. The beds have only to be followed along their strike to yield an unlimited amount of slate.

To conclude, I consider the Chitélí slate good enough for roofing purposes. And that slabs less than ¼ of an inch in thickness and much more than a square foot, superficial measurement, may easily be obtained.

I would recommend, should the working of the quarry be determined upon, that some competent person should be appointed to pass the slates. Native labourers are too indifferent to take any interest in their work, so that no dependance can be placed upon them; and they would just as willingly waste their time in splitting bad slate as they would in splitting good. The employment of one or two skilled slab-men to supervise the other labourers and also to work, would in the end be more economical than trusting to the local abilities of the Chitélí villagers, as they would probably spoil through carelessness an endless number of slates.

NOTE ON THE LEAD VEIN NEAR CHICHOLI, RAIPÚR DISTRICT, by W. T. BLANFORD, ESQ., ASSOC., ROY. SCHOOL OF MINES, Dep. Supdt., Geological Survey of India.

The following is the result of a brief surface examination of the locality near Chicholi at which lead was discovered three or four years since by Mr. Smart of the Revenue Survey. The spot is rather more than 70 miles west of Raipúr on the road to Bhandára and Nágpúr.

The ore (galena) occurs in a well marked vein, chiefly composed of quartz, which traverses the metamorphic rocks. The latter are not well seen in the neighbourhood of the vein, but in the surrounding country consist chiefly of granite or granitoid gneiss and hornblend schist passing into diorite. Besides quartz the vein contains pink felspar in considerable quantities, green and purple fluorspar, and a green mineral, probably epidote. Galena is sparingly disseminated throughout the mass for some distance on each side of the road, and I found slight, but unmistakeable, indications of the presence of copper; small quantities of the green carbonate occurring in several places.

In some parts of the outcrop there is a large quantity of peroxide of iron, sometimes as a coating on the surface, sometimes irregularly mixed with quartz ("gossan"), and evidently resulting from the decomposition of some other mineral. This is a common occurrence at the outcrop of mineral veins, and is, I believe, usually considered a favorable indication by miners, in copper veins at least. But the value of such indications depends greatly upon local conditions. Large masses of peroxide of iron and quartz, or "gossan" as it is termed in Cornwall, are seen just north of a little peak about quarter of a mile north of the road.

The direction of the vein is N.-10°-E.—S.-10°-W.: it forms a series of ridges, some of which are at least 100 feet high above the surface of the ground. I traced the vein for about half a mile north of the high road and for at least a mile to the south.

Beyond the distance mentioned to the north, I could find no signs at the surface of its occurrence, but I did not search far. To the south it doubtless extends beyond the spot to which I traced it, and a hill is seen in the direction in which the vein runs, which may be formed of the quartz.

The width of the vein, as usual, varies greatly. Near the high road, both north and south, it cannot be much less than 30 feet. About a quarter of a mile to the south, this thickness gradually decreases to about six feet. At this spot the veinstone rises like a wall above the surface of the little ridge formed of its quartzose debris, and the direction of its dip, obscure elsewhere, is distinctly seen. It here underlays to the eastward at an angle of about 10° from the vertical, in other words, it dips at 80°. Beyond this, to the south, the thickness probably diminishes still further, as, for about quarter of a mile, the vein can no longer be traced at the surface; beyond that distance it again forms a ridge of some height.

It is simply impossible from the surface examination of a metallic vein, especially in a district where no mines exist, to ascertain what its value may be below the surface. All metallic mines are more or less speculations. Taking into consideration the large amount of veinstone exposed, the proportion of galena seen is small, and unless the quantity of lead ore be greater below the surface, it will not alone pay for the working. It should be observed that the fresh unaltered appearance of the galena found renders it impossible that its paucity is due to the greater portion having decomposed. But larger masses may occur below, and there is also a probability of copper ore being found. The occurrence of the ores in a well marked vein is certainly a most important circumstance, and I may add that it is the first instance of a distinct metallic lode that I have seen in India.

Altogether I think it may safely be stated that there is nothing in the appearances presented by the Chicholi lode inconsistent with the occurrence of a good vein of lead and copper ore below the surface. There are two disadvantages in the locality: the absence of workmen acquainted with mining and want of water, not merely as a motive power for pumps, &c., but for stamps and washing floors. But these are only questions of expense, and should rich ores occur, will readily be overcome.

At Wúrában d, 16 miles east of the Chicholi lode, two rather irregular quartz veins occur, forming hills of considerable size. I saw no traces of ore or of fluorspar in these, but my search was necessarily hurried. The direction of these veins approximates to that of the Chicholi lode.

17*th March* 1870.

Better specimens than before accessible have been assayed, and yielded 9 oz. 19 dwts. 6 grs. of silver to the ton of lead.

THE WARDHA RIVER COAL-FIELDS, BERAR and CENTRAL PROVINCES.

The last notice of these coal-fields was given in the Records of the Geological Survey of India, Vol. II, pt. 4, p. 94. Since that time great progress has been made in the detailed exploration of the field, and it is now possible to give a tolerably accurate estimate of the extent of area over which the coal can be traced, and of the amount which is available, in the vicinity of the river Wardha.

This river Wardha forms the boundary between the Central Provinces, lying to the east of the river, and the 'Assigned Districts' (Berar) and the Nizam's Territories, lying to the west of the river. The same boundary is continued further to the south by the Pranhita, as the stream is called after the junction of the Wardha and Weingunga, and still further to the south by the Godavery, as the continuation of the same stream is called after the junction of the Pranhita and Godavery, near Sironcha.

Previously to the recent exploration the only places where coal had been actually found, were a few points exposed by the cuttings of this river. The whole surface near the river is so covered with widely extended beds of calcareous gravels and conglomerates (? pliocene) and thick masses of sands and clays and often of regur, or black cotton soil, that, as a rule, very few, and these very limited and imperfect, sections are seen and the structure of the country must to a large extent be imagined or built up from these small sections. Although thick beds of coal were visible in the banks of the river, their continuance inland could not be traced, and even where the rocks were exposed, the denudation had been so great, and the thickness of the covering clays, &c., was so considerable, that the outcrops of beds of such marked character as coal and coaly shale of 40 and 50 feet in thickness were entirely concealed. And it therefore was essential that actual borings should be put down. The results of a few of the early trials were given in the notice referred to above. (Vol. II, p. 94).

Shortly after the publication of that notice three additional sets of boring tools were received from Europe, and were at once turned to account. And sometime later, a steam boring machine of Mather and Platt's construction was delivered at Chanda, and preparations were made for working it. I shall now give briefly the principal results obtained.

The two brace headmen who had been sent out from England had both suffered from the climate. Mr. Heppel had a very serious attack of fever, and was for a time dangerously ill. But he got over this attack, I am happy to say, and resumed his work as zealously as before. Mr. Longridge had suffered slightly at several times from the effects of the sun; and I regret to say, the attacks became more frequent and severe, until it was necessary that he should be invalided and sent home at once. The advantage of his aid was lost from the very commencement of the open season. Mr. Bateman Smythe was appointed (10th December) in lieu of Mr. Longridge, and has proved a most efficient and useful Superintendent of the Works. Mr. W. Penn Mather, who had had very considerable experience in boring with the steam boring machines constructed by the firm with which he was connected (Mather and Platt) and who had temporarily come to India, was appointed to take charge of the Steam Borer, and joined in the beginning of February.

Taking up the narrative of the exploration from the time of last report published in these Records, I will now briefly give a notice of the principal facts.

I shall not at present delay to give the full details of the sections cut through at the various holes, but simply enumerate the localities where these have been put down and state the results. The details will more appropriately be given with a more detailed geological report.

Up to November 1869, as already stated, only a few unsuccessful borings, in which nothing but thin unworkable beds of coal had been met with, had been carried out. A deeper boring to the east of Chanda town on the road to Moolh, and on the banks of the Jhurput Nuddi, was then in progress; and this was subsequently carried down to a depth of 248 feet At this depth the progress made with the poor windlass power then at command was so slow, and the importance of determining the existence of coal elsewhere so much more pressing, that it appeared wise to stop this boring, more especially as there was nothing definite tending to show the probability of a change in the rocks within a short distance. The tools were therefore moved elsewhere. The same-section is now being proved by the steam boring machine, with the additional advantage of testing the upper rocks for a considerably greater thickness. The borings to the south of the town of Chanda, although it was evident that they had been put down altogether outside the outcrop or line where the known coal, if it occur, could be traced, were not resumed, as it seemed better to reserve these for the monsoon, when men could find good shelter in adjoining bungalows at a time when it would not be possible to remain with safety in tents. A systematic examination, therefore, of the country extending northwards from the known coal locality near Ghúgús was commenced, and has since then been steadily carried out. One additional bore hole was put down between the pit sunk on the coal near Chandur on the bank of the Wardha and Nokora. This was due west of the village of Ghúgús, and was intended to supply the information which we had been prevented from obtaining in nearly the same place by the loss of the mineral lifter in the boring there. The object of this was to prove the actual amount of variation which the seams showed within this distance of three miles. This variation will be best seen in the accompanying details.

Ghúgús North.

	Feet.	Inc
Black shale ...	2	0
Coal	3	0
Dark sandy shale	3	0
Coal	3	0
Blue shale	5	6
Coal	12	0
Coal with iron pyrites	4	0
Coal	5	0
Shale .	0	6
Coal ..	11	0
White sandstone.		

Ghúgús W. of village.

	Feet.	Inch.
White sandstone .	8	6
Coal	3	0
Shale mixed with coal	2	0
Coal	3	0
Sandy shale and coal	6	0
Coal .	4	0
Coal and shale .	9	0
Coal	7	0
Sandy shale	10	6
Coal, good	9	0
Coal, inferior .	2	0
Coal, good. .	11	0
Sandy shale	0	2
Coal ..	10	0
White sandstone.		

Nokora.

	Feet.	Inch
Black shale	1	6
Coal .	4	0
Sandy shale, with a trace of coal	2	10
Coal	3	6
Dark sandy shale ...	5	4
Coaly shale with coal (bad coal)	3	6
Black shale	16	10
Coal, inferior	4	0
Coal . .	5	0
Sandstone mixed with shale	5	0
Very dark shale ...	3	0
Dark sandy shale ...	2	10
Coal .	21	8
White sandy shale	0	2
Coal	13	0
White sandstone ..	7	8

These borings are about 1½ mile from each other; they are beyond a shadow of doubt in the same general beds and the same coals, whereas the very great amount of change in the thickness and character of the seams within this short distance is very evident. This is a very important point as bearing on the question of the economy of working.

Proceeding northwards, two bore holes were next put down at Telwassa, near the river Wardha. The most southerly of these was intended to prove the beds below the thick coals, and to ascertain, if possible, the actual thickness of rock in this Lower Barákar group. It was carried down to 192 feet, and at this depth, when a few feet more would certainly have reached the Talchir beds below, the mineral lifter was allowed to get jammed, and in attempting to raise it, the steel valve box at the end was forced off and left in the hole, which was then abandoned. Some thin seams of very impure coal were found, as anticipated, just at the base of the series, but nothing worth working.

The second boring was fixed about a mile further to the north, on the east side of the river, and here coal was cut at 68 feet below the surface, (of which 29 were surface soil); and the same series of beds as at Ghúgús, again showing considerable variations, were pierced. Altogether 41 feet of coal of varying quality were cut through in a total depth of 138 feet. (See Annual Report, Records, vol. III, p. 1-1).

Another boring was commenced in the lands of the village of Gowarala, near Bhanduk. This was commenced, under a misapprehension of the instructions given, about half a mile from where it was intended to have been, but was useful, inasmuch as the cutters struck the Talchir rocks immediately under the surface clay, and thus effectually proved the absence of coal there.

Two other borings were put down at points intermediate between the Telwassa borings just alluded to and the pit near Chandur. These were near the villages of Belora and Nilja, both in Berar. Both proved the continuance of the same group of beds of coal and shale, exhibiting quite as markedly as elsewhere the great and sudden variation in its character and sub-divisions.

It was next desirable to prove that the coal found on the Chanda side of the Wardha, and there dipping to the west, did actually extend into the country of Berar on the west of the same river. To the south near the villages of Pipalgaon and Ukni small faults affect the continuity of the rocks, and just opposite the point at which the boring in the Telwassa grounds had been put down, the series has been thrown down to the south of a fault which crosses the river. This has enabled some of the beds higher in the series of beds overlying the coal to be here preserved. And they overlap the coal beds to a greater extent than is seen in the adjoining and more denuded area. To test this part of the field, a bore hole was put down, which, however, was not sufficiently far to the west, to avoid this great overlapping, and which, therefore, only touched the extreme outcrop of the coal beds. Another hole about a mile to the north proved very satisfactorily the entire continuance of the coal beds into the country on the west of the river, or into Berar.

Tracing up the same series of beds further to the north, borings were put down in the lands of Konara. This was in the lower rocks (Barákars) and proved no coal: another boring was put down at Borgaon, also without success. Some three miles further north, a boring was put down on the Berar side of the Wardha at Goari (called also Agashi), but nothing but black coaly shales were found here.

These borings were all in the lower rocks. Still further to the north in Chanda district near the village of Majri, a boring was put down, first to the north of a fault which cuts across the beds there, with a view to proving that side, but without success, and then a second boring was commenced to the south of this fault, where the great overlapping of the beds was partially avoided, and here coal was found at 75 feet from surface, and gave a rough section of—

Dark shale, a little coaly 0·2

Coal 51·8. And having proved this thick coal, we proceeded no further. This thick bed, it must be remembered, is not all fair coal, but is split up with many beds of very varying qualities.

A boring, still in progress, was also put down near Nandori, on the Chanda side of the river to the south of the large area of trap which covers many square miles of country near to and around Wurrora. This thickness of trappean rocks effectually conceals everything beneath them, and looking to the great irregularity with which the coal rocks are overlapped, and the impossibility of drawing any sound conclusion either as to the place or depth below the surface at which coal might be found, fully justifies our putting the entire of this area out of calculation in estimating the extent or quantity of the coal in these Wardha river fields. A boring will be put down to the north of this large area of trappean rocks where the lower beds are again visible over a small area near Panjoorni, a village about six miles north-west of Wurrora and probably near Wurrora itself. But with this exception there will be little use in testing the rocks further in that part of the field *at present*. It is not at all intended to assert that the coal group does not extend under a considerable part of this area, but if it does so extend, the chances of finding it are so uncertain, and the depth at which it probably occurs so doubtful, and in any case so much greater than in adjoining areas that, for the present at least, the coal even, if found, could not be worked to the same advantage or economy as elsewhere.

A boring has also been put down in the Berar country well into the centre of the field and some six miles in a right line from the river Wardha. This was at a place called Rajur, which is near Naith or Nét, and about ten miles to the north-west of Wún town. This was simply intended to test the continuance of the coal under the upper rocks, which cover the whole surface there. Up to the latest reports, 15 feet of coal had been cut into there, quite sufficient to show satisfactorily that the rocks continue.

Two or three more borings will now prove the whole of this northern part of the field with perfect sufficiency, and with detail quite ample as a basis for commencing the actual work of raising coal.

To the south of Chanda, the sections at Balarpur, where good coal is visible at the water level in the river Wardha, in the territories of His Highness the Nizam or on the west side of the river, have been examined. It was concluded from this examination that there was not much prospect of finding this coal extending into the Chanda district, as it had in all probability been very largely denuded or washed away and its place now filled in with beds of great thickness of alluvial clay and sand, &c. Still borings were put down to test the fact, and the rocks were proved at both sides of a marked fault which crosses the section from north-west to south-east, the rocks being down-thrown on the east, but to what extent it was not possible to calculate from the limited exposure visible. These borings proved the existence of a few thin beds of coal, 1 foot to 1½ feet, but nothing worth working.* The full examination of the northern part of the field had then become so much more urgent that the tools were removed there.

All the country south of Balarpur still remains to be examined. There is a certainty of coal occurring in the Nizam's territories in the area between the Pemgunga and the Wardha, and a few borings are there required to test the thickness and quality of this coal. The area stretching from north to south throughout the district of Chanda from east of Wurrora to Bhanduk and Chanda, and southwards by Balarpur to the Wardha near Kirmirri, is all composed of rocks which belong to series above the coal. It is therefore possible that coal may be found to extend under these rocks and so cover a large area. But there is not a trace of these lower coal bearing rocks *visible* anywhere along the line, excepting close to Chanda town. And as the covering rocks dip sharply to the east all along here a short distance only in that direction would throw the coal so deep below the surface that it could not be profitably worked in competition with the more accessible and more favorably placed coal elsewhere. This area ought to be tested by a series of well selected borings at long intervals, and if coal be proved, as I fully anticipate it will be near to Chanda, the indications should be followed up carefully. There is no surface evidence whatever to guide the observer excepting there. I have already mentioned why the borings at Chanda had been deferred until the monsoon weather. But when they are commenced, it will be needful to exercise a little more geological skill than had been shown before, for the holes which were bored were altogether outside or below the horizon of the thick coal which it was sought to prove!

No other group of beds containing coal in a workable thickness has been traced in the field, and none other probably exists. It has been shown that this group of thick beds of shale and coal maintains a constant horizon in the general series, that it is largely and irregularly overlapped by the beds which succeed it, and that with a great amount of variation

* It is stated (Supp. Gaz India, Jan. 15, 1870, p. 30,) that 6¾ feet of coal were proved at a depth of 120 feet from surface, within half a mile of Balarpur!! None of the records of the borings bear out this assertion.

there is still a constancy and continuance of the beds, which is satisfactory. In the former report I gave the results of assays of the coals raised from each successive foot in the boring at Ghúgús; and I showed also what an admirable general index to the value of the coals such assays were. I have had the same done for the coals cut through at Telwassa, and I now give the results of these assays.* It will be seen that the composition of the coal raised here is very similar to that at Ghúgús, and that, as a whole, the coals are of very second rate quality. As shown by assay (Records, Geological Survey, India, vol. II, pt. 4, p. 99), the uppermost seam at Ghúgús was good bright coal. And so it proved on cutting into it in the pit sunk not far off. But like all the bright clean coals of this lower group, it also turned out very brittle and fragile, so that it would bear carriage badly.†

* ASSAYS OF COAL FROM THE CHANDA DISTRICTS.

From No. 1 Seam passed through at No. 2 Bore hole, Telwassa.

Nos.	Carbon.	Volatile.	Ash.	Nos.	Carbon.	Volatile.	Ash.
1	30·9	29·8	39·3	18	44·4	34·6	21·0
2 } 3	42·5	32·3	25·2	19 ...	48·9	30·6	20·5
				20 . .	49·4	30·4	20·2
4 ..	41·6	32·8	25·6	21	50·3	33·4	16·3
5 .	34·2	32·3	33·5	22 ..	44·0	31·8	24·2
6 .. .	35·1	26·7	38·2	23	50·4	31·8	17·8
7 ..	36·9	26·7	36·4	24	50·2	33·0	16·8
8 . ..	33·0	25·4	41·6	25	46·7	32·6	20·7
9 ...	42·4	31·6	26·0	26	51·4	30·6	18·0
10	39·1	29·4	31·5	27 . .	51·3	30·6	18·1
11 ...	43·9	32·3	23·8	28 .	51·2	32·2	16·6
12	46·2	33·4	20·4	29	53·0	30·4	16·6
13 . .	45·4	33·8	20·8	30 .	52·3	33·4	14·3
14 .	43·8	34·2	22·0	31 ..	52·0	32·0	16·0
15 . .	45·9	36·0	18·1	32	48·2	30·2	21·6
16 .	41·9	34·0	24·1	33 .	43·8	27·4	28·8
17 .	37·1	32·2	30·7	34 .	50·1	30·6	19·3

From No. 2 Seam passed through at No. 2 Bore hole, Telwassa.

Nos	Carbon.	Volatile.	Ash.	Nos	Carbon.	Volatile.	Ash.
1	46·3	34·5	19·2	5	44·2	33·5	22·3
2 . .	51·2	32·5	16·3	6	43·2	29·8	27·0
3	43·3	29·0	27·7	7	43·4	31·4	25·2
4 ..	49·3	34·0	16·7	8	47·3	28·6	24·1

All burn similarly to the batch sent last September, *i. e.*, vigorously at first, but after the expulsion of the volatile matter only slowly down to the ash. The ash of all the samples (which has been preserved) is very similar, 25 grains mixed of Nos 31, 32, 33 and 34 on being treated with sulphuric acid, hydrochloric acid, and carbonate of soda left an insoluble residue of 7·5 grains.

On closely inspecting some of the samples some small fragments of a much superior coal may be perceived From No. 28, which appeared to contain some of the largest of these, I picked out sufficient to make a separate examination. This gave the following result :—

Carbon	62·5
Volatile	34·5
Ash	3·0
	100·0

February 28th, 1870 (Signed)

† This brittle coal could be coked with advantage

The coals below that were very inferior, and much that has subsequently been furnished from the sinking at this pit for the use of the steam boring machine is scarcely worthy of the name of *coal* at all, with difficulty keeping up the fire, and not giving steam at all in sufficient quantity. The present assays show that this is the character of much of the Telwassa coal also. One thing is quite certain that, as pointed out long since, any estimate of value based on the duty obtained from carefully selected coal from these will certainly give a false idea of the average value of the whole; while in any ordinary mode of mining, the irregularity of these better beds, and the certainty that they will not continue for any great distance on the same horizon, will seriously interfere with the economic working of seams of such thickness as those we have shown to occur.

It remains to consider what is the amount of coal which may be considered fairly and economically accessible in these Wardha river coal-fields so far as examined, that is, in other words, in the country lying between the Wardha and Pemgunga rivers in the south and the general outline of the trappean rocks which cover everything on the north. If we take this estimate in two distinct portions, as referring to the east and to the west side of the river Wardha, we can then combine the two to get the general results. In Wún district, to the west of the Wardha, there may be estimated to be about 70 square miles of country under which the thick coal may fairly be presumed to extend, and will probably be found nowhere at a greater depth than 120 yards below surface. Now, from this we must deduct a fair proportion for ground cut up by faults and disturbances, and so not likely to yield very profitable return from the working of the coal. If for this we deduct, say, one-third of the area, we will have 45 square miles yielding coal. The average thickness of coal established by the numerous trials may be taken as nearly 40 feet, that is, of coal, coaly shale and beds of varying character taken as a whole. As I have shown, a very large deduction from this must be made, and I believe that an admission of 20 feet would be not only a maximum thickness of workable coal, but be even too high a figure. But taking this as 20 feet of workable coal over 40 square miles, and assuming 600,000 tons as a fair amount of coal obtained from the square mile per foot in thickness, we have $600{,}000 \times 40 \times 20 = 480$ millions of tons of coal, of such quality as it is, available in East Berar at depths below the surface not exceeding say 60 fathoms.

Passing into Chanda we have equally an area of about one and half square miles near Ghúgús, (making the same allowance for disturbed ground as before), and an area of about five square miles in the north of the field. And as the beds of coal are precisely the same, we take here the same estimate of thickness, *viz.*, 20 feet of workable coal. And proceeding on the same data, we will have, therefore, in Chanda, $600{,}000 \times 6{\cdot}5 \times 20 = 78$ millions of tons. This latter result fully bears out what was stated months since, that there was a very much larger amount of coal available in the 'Assigned Districts' than in Chanda, in the vicinity of the Wardha.

We certainly ought not to estimate more that one-half of these quantities of *good* coal.

While engaged in the practical exploration of these coal-fields, I had frequent applications from the Engineers employed in making trial sections and estimates for a proposed line of railway for information as to the position, quantity, and quality of the coal, and as to the general question, which would be the line best adapted to meet the requirements of the case, so as to facilitate the transport of this coal to the existing lines of railway to the north and southwards to the Godavery. It was also asked that the opening up of the cotton country should be borne in mind. Every information was readily afforded from time to time as new facts were ascertained.

But this necessarily led to the consideration and discussion of the best direction in which to carry a line of railway with these avowed objects. The intended point of junction with the Bombay and Nagpúr line was stated to be the Wardha station, and it was at first assumed that the line *must* go to Chanda or through the Chanda district. Long since I pointed out that it required but a very trifling acquaintance with the country to show that by much a larger area of coal existed in Berar than in Chanda, and that it was simply misleading opinion to speak of this coal-field as the Chanda coal-field. I also had occasion to show that the pit which was being sunk to the coal near Ghúgús was quite unnecessary if it were only intended as a means of trial of the coal, and that if intended as a means of working the coal afterwards, it was injudiciously placed, and must be for years to come superseded by others more conveniently located. Such general considerations, however, based on a view of the field at large were of little avail, as compared with 'practical' views, and the work was hastily pushed on. It is to be hoped that the fact, that the Geological Survey have since then pointed out the exact localities for borings and have thus proved the existence of coal within a few feet of the surface, where, they were told, 'such trials were only foolish blunders,' evincing an 'utter ignorance of the teachings of Mining,' and were 'at places where it was impossible that coal could exist,' will be a warning to future enquirers in their researches, and that they will at least try to make themselves acquainted with the geological structure of the area they are about to examine before they trust to preconceived notions or permit themselves to be swayed in their investigation of facts by personal wishes or local tendencies.

The facts stated above are sufficient to show that if the object of a proposed line of railway be to accommodate the largest amount of *coal* traffic, there cannot be a shadow of doubt that that line of railway should go right into the middle of the Wún district.

The consideration next in importance to the establishment of a free communication with the coal-fields was stated to be 'the opening out of the Hingunghat cotton country.'

But what is the Hingunghat cotton country? By much the larger portion of the cotton, which now finds its market at Hingunghat, and all of which is shipped or sent away as Hingunghat cotton, is not grown in the immediate vicinity of Hingunghat, but is brought from very considerable distances. Previously to the opening of the Nagpúr branch of the Great Indian Peninsular Railway, a large share of its supplies was drawn from the country to the north and north-west of the place, and much excellent cotton was brought to Hingunghat, even from Arwee, 50 miles to the north-west, and from the districts in that direction. All this cotton now finds its natural outlet at the nearer marts of Wardha and other places on the line of railway, and scarcely a load, as might have been anticipated, crosses this new line of communication to reach Hingunghat on the south. The country lying between Hingunghat and Wardha must also naturally seek the nearest markets for its produce. For the Hingunghat market, therefore, the supplies must now be derived from the south, south-east, and south-west. But to the south-east, and partly to the south, on the east of the river Wardha, with the exception of a small area near to the town, the country is almost an unbroken jungle for hundreds of square miles. The so-called 'southern road,' although it passes very near to the large towns of Wurrora and Bhanduk, scarcely touches even isolated patches of cultivation for its entire length from near Hingunghat to near Chanda, and again south and south-east of Chanda it sweeps for mile after mile through dense jungle. This belt of forest jungle is in places 30 to 40 miles wide from east to west, and not only does this immense area not yield any cotton at the present, but it is of such a nature that no reasonable hope of its ever producing cotton profitably can be entertained. The surface deposits are derived from the decomposition of coarse ferruginous sandstones and other silicious rocks, which yield a dry thirsty sandy soil, in which the cotton plants cannot flourish. Between this immense range of forests, yielding little but mere jungle produce, and the Wardha river there is a belt of open ground varying in width from two to ten miles, over which are spread thick deposits of alluvial clay and occasionally regur in which a fair amount of cotton is grown. But, as shown, this area is very limited, and the amount of produce must be equally so. On the other hand, to the west of the Wardha, the country is open and cultivated, and produces largely of cotton over an area very many times the extent of the possible cotton yielding country of Chanda. And besides this large area in Berar itself, immediately adjoining to it on the south, is the rich and well known district of Edlabad in His Highness the Nizam's territories, from which, even at present, with all the difficulties of long land carriage (at least 60 miles to Hingunghat) and heavy rivers to cross, by much the most valuable portion of the 'Hingunghat cotton' is obtained. I was led to these considerations myself while engaged in the careful examination of the country (and few persons, if any, see the country with the same detail that geologists do), but I have also been confirmed in this view by those actually engaged in the cotton trade, and who, therefore, were personally able to ascertain the facts. Mr. F. Curwen, agent for Warwick and Company, by far the largest dealers in Hingunghat cotton, stated to me on enquiry that he had given particular attention to this important question of *where* the cotton which came to that market was grown, and had ascertained that taking the ordinary annual sales at Hingunghat as about 30,000 bales, not more than 2,000 out of that quantity were the produce of land near the town, and to the south and south-east of it on the left side of the Wardha river; by far the largest portion and the best quality coming from the Nizam's territories (Edlabad, &c.,) and from East Berar.*

Equally, therefore, if the object be to open out this valuable cotton yielding country by a line of railway, that railway must be carried through East Berar and to the west of the Wardha.

At present the route commonly taken by the carts bringing cotton to Hingunghat is through Wún, crossing the Wardha river to the south-west of Wurrora, and passing through that town to Hingunghat. In this way it is 'that strings of cotton carts may be seen making their way to Hingunghat,' but a very small portion indeed of their loads is derived from Wurrora or Chanda, or any place on the east of the river.

These facts also account for the small and 'not increasing' cotton trade at Wurrora, which is too near to the larger and more important mart of Hingunghat and too far from the main source of the raw cotton to absorb much of the trade. There can be no doubt that if once railway communication be opened up into the Wún and Edlabad country, new marts and presses for cotton will rapidly spring up in more immediate proximity to the places of growth of the crop, where the risks of injury from exposure on open carts and from delays in bringing to sale will be reduced to a minimum. And in this point of view, it may be well deserving of consideration whether the necessarily reduced trade of Hinganghat will then repay the cost of construction of a branch line of railway.

Other special objects to be gained by the construction of a branch line of railway were stated to be the utilization of the timber forest of Aheree and the connection of the Godavery navigation with Central India. To accomplish either of these objects, it is essential that the proposed line should be carried as far to the south as the bottom of the third barrier on the Godavery river, or to the town of Mogéli, or rather Talye or Talawye, on the west, or of Dewalmurri on the east of the Pranhita. To accomplish this, it was proposed to carry on the line, which it was assumed would go to Chanda town, to Kirmirri, where a sound rocky† foundation for a bridge would be obtained, and crossing the Pranhita there to proceed to Mogéli, on the opposite or west bank of the river. How the timber of Aheree which lies away from the river on the east side was to reach the railway on the west I know not. But there is little need to discuss this, for the surface of the country to the south of Chanda town offers physical difficulties, which will prevent any economical construction of a line of railway there. The line, alluded to above, if carried into East Berar could, on the other hand, be prolonged to Mogéli, or Talye, without meeting with any equally serious difficulty. It could cross the Pemgunga above the junction of the Wardha, where the body of water and the cost of bridge would not be one-half of what it is at Kirmirri, and where it would be close to coal.

Exactly the same arguments suggest themselves if we consider the connection of the Godavery navigation with Central India, to accomplish which, the main point would, of course, be to obtain the cheapest and best road to the bottom of the third barrier. But to these may also be added the fact, that there is every prospect of a considerable area of coal in the Nizam's territories between the Pemgunga and the Pranhita, all of which would be economized by a line of railway on that side of the Pranhita, but would be useless or nearly useless if that communication were carried out on the opposite bank, where no coal occurs.

Any advantages anticipated from the introduction of the Wardha coal into the southern parts of the Peninsula (Madras, Hyderabad, &c.,) would be common to either line. But these may be, I think, put out of present consideration altogether. If, on further investigation, the coal known to occur near Dumagudium and to the south of that place prove abundant

* The Tehsildar of Wún reports that the ground under cotton cultivation this year was 28,177 acres: the average produce for each acre was 76½lbs., the total produce 1,077,770 seers = 9,000 bojas, or 18,000 guttas (bales). Besides the above, about 12,000 bojas, or 24,000 guttas, are carried through this taluq to Hingunghat from His Highness the Nizam's territories, from Rajur, Manikgur, and Edlabad taluqs.—*April* 1870.

† It is a singularly perverted misapplication of a tolerably well known geological term to speak of the wide spread area of crystalline rocks which are exposed at Kirmirri and to the east as a "gneiss dyke." The only real use of such special terms is to convey accurate ideas without the necessity of long descriptions, but if employed when their meaning is not known they must have exactly the opposite effect, and must lead to confusion and obscurity.

and of fair quality, there would be no hope of contending with that field for the supply of Madras or elsewhere to the south. And it is greatly to be regretted that Colonel Haig was not supplied with the means of investigating this very important question during the present year. And in any case coal does occur many miles to the south of the Chanda coal in the Nizam's territories, which is much more conveniently placed for meeting any demands from the south.

Other considerations have been introduced incidentally as it were, which may be just alluded to. 'The rich iron ores of Chanda would before long,' it is said, 'be smelted at foundries near the coal-field.' Whether such a rapid introduction of iron works can fairly be looked for under any circumstances is more than questionable. That rich iron ores do exist in the Chanda district is well known, and equally that they exist in practically exhaustless quantity (there is a whole mountain nearly a mile long of magnetite in one place), but these ores do *not* occur near the coal-fields. There is also hæmatite ore in the Yanak hills, near to where the line of railway if carried down there ought to cross the Pemgunga, and near to coal.

In all these remarks I would say that I have purposely avoided entering on any question of the comparative facilities, or comparative economy of construction of any such line. Some years' experience in laying out and making railways might justify my discussing these points, but I have known so many instances of absurd mistakes as regards sections and estimates for such works based on a mere inspection of the ground, or put together on the information of others only, that I would not venture to offer an opinion without actual survey. Nor is there any necessity to do so. Trial sections have, I believe, been taken over both the lines referred to, and I am much mistaken if these sections have not shown how entirely below the mark the first estimate of the cost was. But, *cæteris paribus,* I merely wish to assert, that a line of communication direct from Wardha into East Berar will accommodate any likely traffic in coal, and will open out the cotton country infinitely better than a line direct to Chanda, or through the Chanda district.

I cannot close without noticing how much, in my opinion, this matter has been obscured by the unhesitating adoption of the term of the Chanda coal-field. It so happens that just there the territory immediately adjoining is under a separate government, and belongs to a different jurisdiction, and the very existence almost of the Berars has been scarcely alluded to in discussing lines of communication, which were to be designed for the benefit of the country at large. But geological formations are not coincident with political boundaries fixed for the convenience of man. Such examinations acknowledge no fiscal limits; we have but to ascertain the facts carefully, and then to state them freely, convinced that any attempt to force the teachings of those facts into a preconceived groove of local tendencies must fail sooner or later, as does every such effort to run counter to the laws of nature.

Whether even the large extent of coal proved to exist in Berar, of a quality such as it is shown to be, and varying so much as it does at different points, will repay the charges for construction of a line of railway, is, I think, worthy of much closer consideration than it has yet received. The calculations which have been gone into in great detail, although correct in themselves, are based on data, which even the few weeks that have since elapsed show to be fallacious. English coal was taken as costing at Bombay *on an average* Rs. 30 per ton; at Nagpúr Rs. 60 to Rs. 70. And it was calculated, even allowing for the use of two tons of local coal instead of one of English, that at any place east of Bhosawul a saving of £1 6*s*., or Rs. 13 per ton, would be effected by the use of Ghúgús coal. The price of English coal at Bombay is now, April 1870, Rs. 14 per ton, that is, less than one-half the price calculated, or a difference in first cost greater than the estimated saving!! I do not believe that this rate can be maintained, but it is quite possible that the continued use of the Suez Canal will tend to reduce very considerably the average cost of English coal at Bombay.

This one item alone would totally upset all the calculations of cost, of profit, and of traffic even. And before it can be asserted that a branch line of railway to the Wardha river coal-fields will even repay interest on the cost of its construction, vastly more careful and more widely gathered statistics, both as to cost and amount of traffic than have as yet been hastily procured, or at least published, must be sought for.

May 1*st*, 1870. T. OLDHAM.

In this case the outcrop of the seam may pass for a long distance down the river, being concealed by the sand in the bed, which is here of great width. All dips seen appear to be lower than those at the outcrop of the coal, and it is highly probable that the amount of inclination may be higher at this spot than it is elsewhere, and the direction of the dip different in consequence of the fault close by. The circumstance already mentioned of the variation in both amount and direction of dip at different parts of the outcrops in the coal seam itself is in favor of this view.

So far as an opinion can be formed on these very imperfect data, it appears that the rocks associated with the coal cover a large tract of country, and it is improbable that so thick a seam should thin out within a short distance. It is, however, quite in accordance with our knowledge of similar seams in other parts of India that the exact thickness, the quality of the coal, and the proportion of good coal to inferior coal and shale should be highly variable.

If the coal seam be continuous it should be found west of the Hasdo throughout a tract from one to two miles broad, extending probably in a west-north-western direction from the river, the southern boundary of this tract passing through the more northern of the two outcrops seen in the river. East of the stream the seam should underlie the village of Korba and the river bank for at least a mile below and probably one to two miles above the village, and it may extend for an indefinite distance to the eastward, but it is possibly at a considerable depth below the surface throughout a large proportion of the area.

It is evident that before attempting to open a coal mine, boring must be resorted to in order to ascertain the extent of the seam and its depth beneath the surface. The best places for boring will depend upon whether it is desirable that the coal should be extracted on the east or on the west side of the Hasdo.*

If to the west, as the strike of the rocks is somewhat uncertain, the first boring should be made about a quarter of a mile west-north-west of the spot where the more northern outcrop appears in the river. Although the strike at the outcrop is west by south, there can be but little doubt that the normal strike is north of west, and that the alteration is due to the fault. Should the coal not be found in the first boring within a depth of 200 feet, two others, one 300 yards further north, the other at the same distance to the south, should be made. When the true direction of the outcrop is ascertained, it will be well to continue the borings along it at distances not exceeding half a mile apart, as any slight change of direction coupled with the high dip (if the latter be constant) will take the coal below the depth to which borings can most conveniently be made. There is also a possibility of other faults occurring besides that seen in the river.

On the east of the Hasdo the question is simpler. The fault so frequently referred to must either pass through the village of Korba or just south-east of it. West of the fault a boring behind the zemindar's residence would probably pass through the seam. East of the fault the best place for boring is at a spot where sandstone occurs in the left bank of the river below Korba, due east of the more southern outcrop on the right bank. Owing to the rather high dip, these borings should be made to a depth of about 400 feet, if coal be not found sooner. But, as I have already suggested, it is far from improbable that the high dip is local, and that on the left bank of the Hasdo the inclination is less, in which case the coal may be found at a moderate depth. Other borings, if the above are successful, may be made at intervals along the east bank of the stream below Korba. To the north of Korba the coal for some distance is probably at a considerable depth, but if continuous, it must again rise towards the surface between one and two miles north of Korba. It is, however, impossible to indicate with accuracy a good spot for boring in this direction. The best plan for examining the ground would be to put down a series of borings along a line running north-north-east from Korba at half mile intervals.

Facilities for mining.—The dip of the seam where seen in the river, although considerable, is by no means so high as to be any impediment to mining beyond its effect in rapidly increasing the depth of the seam below the surface. The sandstone above

* In case of a railway bridge being necessary across the Hasdo, Korba appears to be a more favorable spot than any other in the neighbourhood, as the breadth of the river is moderate and a considerable portion of the channel rocky. For several miles above and below, the breadth is very much greater, and the bed a wide expanse of sand.

the coal is firm and massive, and will probably furnish a good roof. The coal appears compact, the joints or "backs" are rather irregular, but still sufficiently marked in general to facilitate mining. Some of the very best and brightest coal is as usual rather brittle, but the greater portion of the seam bears carriage well. This bright coal, as I have mentioned, makes a very fair coke, and in that state is far less brittle, besides being much lighter and consequently costing less for carriage. The cost of coking in ovens heated by waste coal would be very trifling.

In consequence of the absence of bands of shale in the overlying sandstone, the quantity of water may be rather larger than usual, but in the small pits dug in the bed of the river the coal did not appear in general to be porous.

In mining a seam of such thickness as this, especially where the proportion of good coal is large, if the roof prove as sound as will probably be the case, it will be an important economic question whether some more advantageous method of mining cannot be adopted than that of removing a small section of the seam, not exceeding twelve feet in height, by "long wall" or still worse by "post and stall," more especially as it is highly improbable that the best bands of coal will be found for any distance on the same horizon, a most serious draw-back to mining on either of the two English systems mentioned. It would, however, be premature to enter into this subject at present, but the methods adopted for extracting the thick deposits of lignite or brown coal found in parts of Germany are deserving of attention.

Conclusion.—I have endeavoured to show my reasons for the opinion I have formed as to the Korba coal. My conclusions are briefly, that both the quality and mode of occurrence are favorable. In thickness, in quality, and in the proportion of good coal to inferior coal and shale, the seam surpasses that near Chanda. The question of the extent over which the coal extends must be ascertained by boring.

CAMP KORBA,
18*th April* 1870.

The following table gives the result of assay of the coals referred to in Mr. Blanford's report just given :—

	Carbon	Volatile	Ash		Carbon	Volatile	Ash.
a	38·7	26·6	34·7	*g* ...	46·4	23·6	30
b	45·8	22·4	31·8	*h*	57·5	25·2	17·3
c	42·3	25·2	32·5	*h* lower 2 ft * ...	60·5	29·5	10
d	39·6	21·6	35·8	*i*	46·5	22·2	31·3
e	47·8	28·2	24	*j* ...	53·3	27·2	19·5
f	32·8	21·4	45·8				

9*th May* 1870.

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* Cakes slightly.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1872. [May.

NOTE ON THE GEOLOGICAL FORMATIONS SEEN ALONG THE COASTS OF BILÚCHÍSTÁN AND PERSIA FROM KARÁCHÍ TO THE HEAD OF THE PERSIAN GULF, AND ON SOME OF THE GULF ISLANDS, *by* WILLIAM T. BLANFORD, A.R.S.M., F.G.S., *Deputy Superintendent, Geological Survey of India.*

The coasts of India, so far as the geology is concerned, may be now said to be fairly known, but hitherto, so far as I am aware,* very little, if any, information has been published concerning the rocks seen on the coasts of the Gulf of 'Omán' and the Persian Gulf. Through the labours of Dr. Carter,† we have a fair knowledge of several points on the south-east coast of Arabia, but the only port visited by him eastward of Rás el Hád, the south-eastern corner of the Arabian peninsula, was Maskát. Dr. Cook has given descriptions of the country around Khelát and several other parts of Bilúchístán, but he did not examine the coast, and Eastern Persia is almost a *terra incognita* even to geographers.

Through the kindness of Mr. H. Walton, Director of the Makrán Coast and Persian Gulf Telegraph, I have had an opportunity of accompanying him in his tour of inspection of the telegraph offices along the Bilúchístán (or, as it is more commonly called, Makrán) and Persian coasts,‡ and of visiting and briefly examining several points of interest, besides the neighbourhood of the various telegraph stations. From the steamer, whilst passing along the coast, the greater portion of the rocks forming the utterly barren hills have been sufficiently well seen to enable them to be recognised as belonging to the same peculiar formation which I examined at Rás Malán, Hormárá, Gwádar, Chárbár, and Jáshk, east of the entrance to the Persian Gulf, and which I believe to be the same as that which I found on the islands of Kishm and Hanjám in the south-eastern part of the Persian Gulf, and on Khárak Island near Bushehr. The mountains behind Bandar Abbás and Lingá on the north-east coast of the gulf are composed of rocks so much resembling in appearance those of the Makrán Coast that I think it probable, with the exception of a peculiar salt formation in Hormuz and the neighbouring islands to be presently described,

* This paper being written away from books of reference, I may have overlooked some previously published description of parts of the Makrán or Persian Coast. It is probable that brief notices of the rocks occur in some of the geographical papers on the shores of the Persian Gulf.

† Jour. Bom. Br. R. A. S., Vol. IV, p. 21, and Geol. Papers on West Ind., p. 551.

‡ I take this opportunity of expressing the very great obligations I am under to Mr. Walton for the facilities afforded to me for examining the different places on the shore, at some of which he stopped solely for the purpose of enabling me to visit them; and I am equally indebted to Captain Bishop, Commanding H. M. S. *Amberwitch*, for assistance of all kinds, the use of boats whenever I wanted them, and especially for aid in dredging.

that the whole Bilúchistán and Persian Coast from near Cape Monze to Bushehr, a distance of over 1,100 miles, and the islands lying off it, consists of the same group of rocks. This group, which is of tertiary age and newer than the nummulitic series, may conveniently be named the Makrán group.

The salt formation in Hormuz and other places in the neighbourhood is far more ancient. Singularly enough, no nummulitic rocks are known to come down to the coast throughout the area described, although Cape Monze near Karáchí consists entirely of them, and I learn from Major St. John that they form the second range of hills inland of Bushehr, between that port and Shiráz, and thence extend far to the southward, perhaps nearly or quite reaching the shores of the gulf near Rás Mutáf. The only other formation observed on the coast is the sub-recent shelly limestone or calcareous grit, identical with that found on the western coasts of India and known at Bombay as "littoral concrete" or "shell concrete." There are thus, in descending order, so far as I have seen, three distinct systems of rocks exposed on the Makrán and Persian coasts; these are, in descending order: 1, littoral concrete (sub-recent); 2, Makrán group (post-nummulitic); 3, Hormuz salt formation (of unknown age). I shall describe each briefly, premising that the Makrán group is the prevailing formation throughout the coast, the other groups being merely local.

Hormuz salt formation.—The island of Hormuz, once the centre of the trade between India and Europe, is one of the most singular places on the surface of the earth. Except at a few spots on the sea shore, it is destitute of vegetation, and consists of a mass of craggy hills of singularly confused forms, but of small elevation, with very few peaks rising above the general level, and of brilliant colours, scarlet and purple predominating. One peak, a little above the rest, is of pure white, as if covered by snow, and some valleys on the westward side of the island are equally filled with a white mass, suggestive of glaciers. Other peaks are black.

In the portion of the island south of the old Portuguese Fort, which I examined, the mass of the hills consist of rock salt, more or less pure, frequently mixed with a reddish earth. Beds of volcanic origin, dolerites and trachytes, some of them much decomposed, are associated with the salt, and some shales and sandy beds are also interstratified. All apparently belong to the same series, but the rocks are much disturbed, beds of salt and volcanic bands alike dipping at high angles. At the spot examined by me the average dip is about 50° to the north-east. On the opposite side of the island, the strike appeared to be nearly the same, but the dip is reversed.

Micaceous iron in abundance is associated with the salt, and I found crystalline masses of anhydrite, and peculiar isolated crystals of carbonate of lime. I had not time to visit the white peak, but I have been assured that it consists of salt.

In the Island of Hanjám, salt-rocks crop out, every here and there, from beneath the Makrán group. They may always be recognised by the surface having fallen in through the washing away of the salt, and the consequent formation of peculiar large crateriform hollows. Upon the beds of the salt series the tertiary rocks of the Makrán group, or at least beds which I believe to belong to that group, are seen resting quite unconformably.

The same unconformity is seen in the large island of Kishm or Jezirah at Tawilah, in which are several outcrops of the salt series, easily recognised, even at a distance, by their red colour and irregular craggy surface, the latter due to their being so largely composed of soluble rock salt. Towards the northern end of the island, at a spot which I visited, there are some large salt caves dug in a bed of very pure rock salt, from which considerable quantities of the mineral are removed for export.

I found a small outcrop of the Hormuz rocks on the island of Túmb. The only place on the main land of Persia at which I recognised the existence of this formation was at Rás Bostánah, north of Lingá. I did not land, but the Commander of the *Amberwitch*, Captain Bishop, took the steamer as close to the shore as he could with safety, in order to enable me to see the rocks, and their appearance and surface were characteristic of the salt series.

I can form no conception of the age of these salt beds: they are much disturbed, but beyond the fact of their being much older than the Makrán group, there is nothing to indicate their geological relations. They appear to be unfossiliferous.

Makrán group of beds.—Cape Monze on the western frontier of Sindh consists entirely of nummulitic rocks, chiefly limestone. Farther to the westward, the beds near the coast have an appearance entirely different from that presented by the nummulitics, the distinction being so great that it may be recognised at a distance of many miles. The prevailing rock along the Makrán Coast is a pale grey clay, more or less indurated, occasionally intersected by veins of gypsum, usually sandy, and often calcareous, occurring in beds of great thickness. With this clay are interstratified bands of shelly limestone, calcareous grit, and sandstone, but these usually form but a small portion of the mass, although their greater hardness makes them conspicuous at the surface. In all sea cliffs and inland scarps the clay is well exposed; thus the magnificent cliff, nearly 2,000 feet high, at Rás Malán, is almost entirely composed of it. From its softness, it disintegrates rapidly, and the usual features of the scenery are peculiar and characteristic. Where the rocks of the Makrán group are horizontal or slightly inclined, the hills near the coast, as at Rás Malán, Hormárá and Gwádar, are more or less flat-topped, the upper surface composed of one of the hard calcareous beds, which are usually dark coloured or become so where exposed, forming a stony plain, often broken up by ravines. Here and there, especially if the harder beds are few in number, isolated blocks of fantastic form stand up above the general level of the hills, precisely as in the horizontal traps of the western ghâts, although the pale, almost white colour of the Makrán clays gives them a very different aspect from that of the black basalts. The scarps around the hills are white or grey clay cliffs, often much concealed by the dark coloured débris of the calcareous bands.

Where, on the other hand, as is sometimes the case,—*e. g.*, near Jáshk and some miles east of Hingláj,—the rocks of the Makrán group dip at considerable angles, the hills formed of them assume a very serrated appearance in consequence of the rapid washing away of the clays and the prominence given to the harder bands. Although this appearance is peculiar, it is less characteristic than that of the flat or nearly flat-topped hills surrounded by pale coloured cliffs.

Locally, a peculiar appearance is produced by vertical veins of gypsum standing up in the clays, but this does not appear to be common.

The "mud volcanoes" of the Makrán Coast have long been known: they are numerous and those seen by me at Chandrakúp appear to consist of the characteristic clay of the Makrán group, which being mixed with salt water, is ejected by means of gas, and dries into cones.

Fossils of Makrán group.—The Makrán beds are evidently of marine origin. They are usually highly fossiliferous, the most abundant fossils being species of *Ostrea*, *Pecten*, and *Balanus*. Bivalve Mollusca, especially forms of *Arca* (several species), *Cardium*, *Lucina*, and species of the family *Veneridæ*, *&c.*, abound, but very often only occur as casts; Gasteropoda, though far from scarce, are less common, forms of *Cerithium*, *Turritella*, and *Natica* being perhaps the most prevalent. No *Brachiopoda* or *Cephalopoda* have been noticed. *Echinodermata* appear far from scarce; corals also occur, but in no great abundance, whilst *Foraminifera*, although common, are chiefly represented by minute species, the only abundant form observed of frequent occurrence, which is not of very small size, being an *Operculina*. If any fossil character can be selected as distinctive of the formation in general, it is, I think, the frequent occurrence of the cirripede *Balani*.

It must be borne in mind that all remarks upon the fossils of the group are founded on very few and scattered observations, and that any conclusions now drawn may require modification when the rocks are farther examined. Still I think it may be safely stated that the fauna differs entirely from that of the nummulitic rocks. Only a small minority of the fossils obtained can be identified with the species figured in D'Archiac and Haime's "Animaux Fossiles du Groupe Nummulitique de l'Inde;" and, of these, it remains to be seen whether all really occur in the nummulitic series, for it has long been suspected that some of the species figured by the distinguished French geologists are derived from a higher group than the true nummulitics. The general facies of the Makrán fauna is utterly different from that of the lower tertiaries; the commonest and most characteristic fossils of the nummulitics are *Foraminifera*, especially *Nummulites* and *Alveolinæ*; the most abundant shells in the Makrán group are barnacles, oysters and scallops. No junction of the two series has hitherto been observed, but it may be safely asserted that the Makrán group is newer than the nummulitics, for while the fauna of the latter appears to be nearly, or entirely extinct, at all events in the shallow seas near the coast, several of the Makrán fossils appear identical with species found living, in water of moderate depth, along the shores of Bilúchístán and the Persian Gulf.*

It is possible that the Makrán group represents the Milliolitic deposits of Káthiáwár and the south-east coast of Arabia. Some of the calcareous bands of the former have very much the appearance of "Porbunder stone," and seem to consist, like it, of the casts of minute *Foraminifera*.

Persian Coast of the Gulf, and the neighbouring islands.—It must be borne in mind that, whilst I have little doubts as to the identity of the formations on the Makrán seaboard from near Somiání to Jáshk, my suggestion that the beds seen along the north-east coast of the Persian Gulf belong to the same group rests chiefly upon their appearance from a distance, a very imperfect guide, and one upon which I only hazard an opinion because the rocks have a very peculiar appearance. The only places, where I examined the rocks, were in the islands Hanjám,† Túmb and Khárak. At the first named, the beds closely resemble some of the Makrán group, but the pale clay is in comparatively thin beds and highly calcareous, so as to form a hard compact rock. Of fossils besides the characteristic oysters, pectens and barnacles, a *Cidaris* occurs with very peculiar spines, which are scattered in great numbers throughout one bed in the valley behind the telegraph station. The spines vary so greatly that scarcely any two are identical in form, all have the terminations expanded, and either flattened or cup-shaped, with numerous finger-like processes from the end.

At Túmb, nearly the whole island is covered with subrecent littoral concrete. Beneath this clays are here and there seen, which very probably belong to the Makrán group.

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* By the assistance of Captain Bishop, I have been able to collect with the dredge a considerable number of the Mollusca inhabiting the sea bottom. These will doubtless aid in making out the relations of the Makrán beds.

† Henjam, Henkam and Angam of various writers.

The island of Khárak* near Bushehr consists of rocks precisely like those of Hanjám. Littoral concrete covers the level ground near the coast; from beneath it rise thick whitish grey beds of fine argillaceous limestone, or very calcareous clay, capped by coarse dark coloured gritty limestone. Except that the clay is more calcareous, there is no difference in mineral character between these rocks and those seen at Rás Malán, Gwádar and Jáshk. Fossils abound on Khárak, and again the most abundant are species of *Ostrea*, *Pecten* and *Balanus*. More careful comparison than I have had time for hitherto is necessary in order to ascertain whether the species are identical with those of the Makrán Coast, but I think they are, and if any of them are not the same, they are certainly closely allied. With these occur two species of *Spondylus* and several Echinoderms, amongst which the principal are two kinds of *Clypeaster*, a *Scutella* and an *Echinus*. One form of *Clypeaster* is near *C. Halaensis*, D'Archiac and Haime; all the other fossils appear to be distinct from those figured in the "Animaux Fossiles du Group Nummulitique de l'Inde" The *Balanus* may certainly be *B. sublævis*, but the difficulty of comparing fossil *Balanidæ* is well known.

Littoral concrete.—This is an impure loose textured limestone, abounding in shells, casts of shells, and corals of very late tertiary or subrecent date. The majority and perhaps all of the shells found in it are identical with those now common on the coast. It frequently resembles in texture the well known *Calcaire Grossier* of the Paris basin, and, like that rock, is an excellent building stone, indeed several of the towns on the Persian Coast, *e. g.*, Bushehr, are built of it. It usually occupies flat or nearly flat ground close to the shore, and but little raised above the level of the sea, and it is, doubtless, in many instances, simply a raised coral reef.

This formation occurs on the western coasts of India here and there, as far south as Bombay at all events. I did not notice it at the points visited on the Bilúchistán coast, though I am disposed to believe that it is represented near Gwádar by a rather argillaceous bed, of which I have seen fragments abounding in shells. At Jáshk on the Persian Coast of the Gulf of 'Omán, it is well developed, and forms a low cliff about 20 feet high. I found it on the east side of Hormuz, on Hanjám and Kishm islands, and the greater part of the surface of Túmb island appears to be formed of it, it being here, if I am right in the identification, raised much higher above the sea than usual, and slightly disturbed. Bushehr is built upon it, and the eastern side of Khárak island is composed of it. In the last named locality the island is partly surrounded by a "fringing" coral reef, so that the similarity of the raised reef forming the "littoral concrete" and that now existing around the island is striking.

The chief geological interest attaching to this formation is derived from the evidence it affords of recent elevation of land. Reasons will be given in another paper for believing that in this respect the western shore of the Gulf of 'Omán differs from the eastern.

Camp Gwádar, Bilúchistan, January, 1872.

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* Khárg, Karack, Khárij, &c., of various maps. The names in the Gulf are mostly Arabic, and I am informed that where the Arabs use j, the Persians employ k. Thus Kharak or Kharij, Hanjám or Henkam.

NOTES ON A TRAVERSE OF PARTS OF THE KUMMUMMET AND HANAMCONDA DISTRICTS IN THE NIZAM'S DOMINIONS, *by* WILLIAM KING, B.A., *Deputy Superintendent, Geological Survey of India.*

Country bordering right bank of Godavery.

The country referred to in these notes is a moderately elevated and rather thickly jungle-covered tract to the westward of the Godavery river, and lying generally along, but to the south of, the 18th parallel of north Latitude.

Already referred to in Records.

That part of the tract adjacent to the right bank of the Godavery has been already referred to by my colleague Mr. W. T. Blanford.*

Observations mostly made along path from Pálúncha to Narsimpet.

A path traverses the region in a general west-north-west direction from Pálúncha in Kummumet, to Narsimpet in the Pákhál talook some thirty miles east of Hanamconda; and it was along this route that my observations were made, for except around the few villages, up some side paths, or in the dry water-courses, it is, at present, almost impossible to see anything of the country owing to the prevalence of thin tree jungle and undergrowth.

Inhabitants belong to "Koi" tribe.

The few people who inhabit this country are of the "Koi" tribe, which is at present more generally confined to the Bastar Territory to the east of the Godavery.

I took up the further examination of this country at Pálúncha, in the neighbourhood of which place Mr. Blanford had been last season.

Kamthi Sandstones.

Pálúncha is on the coarse sandstones of the Kamthi sub-group already described by Mr. Blanford as extending thence down to Ellore in the Godavery District. These rocks, however, only extend a little distance from the village; and the path to Yellambile passes on to rocks of the

Crystallines.

"Crystalline series," gneiss of different kinds showing at rare intervals out of the superficial deposits covering the low-lying and slightly uneven country.

Sub-crystallines at Yellambile.

Near the crossing of the Kinnerammi Vágú, or a short distance higher up the river, there is a good display of rocks which are not so clearly of the gneiss series as those already passed over; and these are found to be associated with highly altered quartzites forming the low hill ridges lying to the west and north of Yellambile and continuing northwards into the lofty group of hills lying between the villages of Munderkheil, Oolavanoor, Mullawárum, and Mámla.

Oolavanoor range, of Vindhyans as well as Sub-crystallines.

Mr. Blanford has noted (on his working map) that part of this range may be of Vindhyan rocks. The southern flanks, at any rate, are made up of quartzites, slates, and schistose beds, which though they have a much more highly altered character than the generality of the Vindhyans, are still not sufficiently metamorphosed to be included in the gneiss series. Occasionally, it is true, some of the quartzites and schists are remarkably like ordinary well-laminated gneiss; but the general aspect of the series is decidedly more Vindhyan in its character.

Belt of Sub-crystallines between Yellambile and Koyergoodium.

The series forms a distinct belt of rocks, having a north-north-east south-south-west strike, between Yellambile and Koyergoodium† (some 9 miles north-west) difficult to be defined by good boundaries

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* Records of the Geological Survey of India, Vol. IV, parts 2, 3 and 4.

† As a rule, the names of places as they are given in the sheets of the Indian Atlas, are adhered to in this paper when they are found to agree with the names given by the people. In the region under description the people say *goodium* or perhaps *goodyim*; I have never heard '*goodum*,' or *gudem*.

from the gneiss between it and the Godavery, but still separable by constitution and general *facies*.

Same series in Bellary and Nellore Districts.

I have (in previous years) already observed a small patch of like rocks on the eastern edge of the Bellary District, just underneath the western scarps of the Poll Conda range of hills, south-south-east of the Chittrawutty river as it enters the Kadapah District. Here, they are quite distinct from the adjacent granitoïd gneiss and the superincumbent Vindhyan quartzites. Again, on the western edge of the Nellore District, south of the Pennair, there is an extensive belt of similar rocks which I have doubtfully mapped for the present among the Vindhyans of that part of the country.

At Yellambile, includes limestones with Eozonoïd structure.

Close to Yellambile, however, the series is rendered extremely interesting from its including numerous beds of grey limestone which show to the unassisted eye a structure, or arrangement and constitution of the laminæ, exceedingly like that of the *Eozoon Canadense* of still unsettled origin.

A short distance (some 500 yards or so) north of the village, there are several beds of limestone cropping up in the jungle, on either side of the path to Munderkheil. They are striking about east by north, west by south, and are either vertical or dipping at high angles north. or south; while they are traceable to the northward for some short distance, and southwards as far as Gutmulla. Ridges and bands of highly altered and crushed quartzites run between the bands of limestone strata.

Also at Bungarchilka.

Again, some 8 or 9 miles north-west, at the villages of Bungarchilka and Koyergoodium, there is a further exhibition of limestone beds of the same kind; but they do not show the Eozoonoïd structure so plainly.

Aspect of limestones.

Generally, the beds are of pale (weathering darker) grey and white laminated sub-crystalline (not saccharine or granular) limestone; the laminæ running easy or parallel with the strike. This, for instance, is the style of the beds nearest to Yellambile; but almost immediately north there are other beds forming a broad belt traceable south-west almost to the Kinnersammi Vágú, which are not simply laminated but have their layers of different matter arranged in waving and undulating lines, rapid contortions, lenticular masses with enveloping laminæ, and knots of all forms. The undulations are equally various on surfaces across, or with the strike.

The harder laminæ, still soft enough however to be scrached with a knife, stand out well on weathered surfaces; and they appear to consist of some form of *Pyroxene*, and are generally of a grey or greyish-green color, and again at times quite white. Some of the laminæ are occasionally of a more decided green color, and they then are possibly *serpentinous*, but this is rare. They are equally unaffected by acid on fresh or exposed surfaces.

The outstanding layers are also themselves finely laminated; and as they widen out often to half an inch or more, they assume a granular form, and are occasionally fringed on one edge. A number of such layers often run together and thus make up a broad seam of irregular laminar-granular structure.

Though not a particularly bright-colored rock, it still shows these characters on half polished surfaces (I could only grind them down so far in camp), and they are then if anything more Eozoon-like.

Much of this limestone is more or less micaceous, and is then somewhat schistose; but neither the direction of the schistose surfaces, nor yet the cleavage which is also exhibited have anything to do with this lamination which appears to be as distinctly sedimentary as the lamination in any ordinary aqueous rock.

This existence or not of Eozoonal structure must now rest on that closer examination of the rock specimens which could not be made in the field.

Continuation of route past Bungarchilka.

From Yellambile the path runs north-west to Bungarchilka. Thence, after going north for a mile or so, it passes round the northern end of the quartzite ridge north-west of the village, and then enters on Kamthi sandstones.

Kamthis again.

These are lying in easy undulations, or nearly flat, possibly with a general dip of from 5°—10° north, or north-eastward. They cannot be of much thickness between their eastern edge near Bungarchilka and the village of Arlapully, the next place of any size on the road; but they attain a much greater thickness in some ridges and high hills to the north, on whose steeper slopes the lines of out-crop of the beds are very well displayed.

To Arlapully.

Change in sandstones beyond Arlapully.

Arlapully is noticed* by Mr. Blanford as a place where some fragments of coal had been found. I did not know this until some time after having left the village, or a closer examination might have made. However, in the next march, *viz.*, from Arlapully to Goondal or Goondala (some 10 or 12 miles west north-west), there is a gradual change in the appearance and character of the sandstones, even in the rare cases in which they are exposed to view.

Barakars.

These become rather paler-colored, less coarse and tufaceous in their texture and full of iron concretions, when they are indeed very like the Barakar sandstones of Lingala and Madaveram on the Godavery.

The path from Arlapully crosses the Kinnersammi Vágú at the confluence of the Jáléru (from the north), and then it keeps pretty close alongside the right bank of the main stream until it again crosses the river just before passing through the village of Mootapooram.

At Mootapooram.

At this crossing there is a good display of thick-bedded grey and yellow sandstones, some of them rather fine-grained and not unlike Barakars; indeed, from the fact of the beds undulating so easily and there being an evident general dip of low degree to the east and north, throughout the Kamthis up to this, it is highly probable that these pale beds are really of the lower series.

Possibly Coal rocks.

The above is what I noted at the time of passing the place. Since then I have seen the coal area north of Kámárum, to be described further on, and I am still of opinion that at Mootapooram or close by, we have true Barakars, and it is at this village until the bed of the Kinnersammi Vágú has been examined more closely that trial borings might be put down with advantage, if it ever become necessary to search for coal in this wild region.

Easy lie.

The beds are rolling about easily with a dip of 5° or 6°, about north-west, though it is difficult to say what is the true direction of the dip in such irregular beds as these are.

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* Records, Geological Survey of India, Vol. IV, Part 3, p. 82.

It is even possible that a seam of coal may show in the place where the large pool of water lies at the crossing; for, I found that the pools of water on the coal area of Kámárum* are all lying on the seams, or close by.

Perhaps a seam of coal at crossing of Kinnersammi Vágú.

That we are near the bottom of the Kamthis, if not below them altogether, at Mootapooram, is soon evidenced, for the large village of Goondala, about 4 or 5 miles further west north-west, is quite close to Vindhyan slates and quartzites. These form the main hill range, a mile or more south-west of Goondala; and a low plateau ridge, immediately west south-west, is made up of coarse, ferruginous, dark-colored Kamthi sandstones.

To Goondala, near edge of Kamthis.

No trace of Barakars was seen in this neighbourhood, little rock being visible in the open flat country around. My examination was however very brief and superficial, as owing to the dryness of the season, I was hurrying on to examine the Kámárum field before all the water in the pools should be dried up.

Barakars not seen.

Goondala is the only village proper on the route; there is a bazaar, &c., and the inhabitants are not exclusively "Kois," as is nearly always the case with the other villages, except Arlapully, where also there is a mixed population.

Continuing westward from this for a couple of miles, there are a few villages, among them Lingoogooram or Lingoogoodium, all of which are just on the boundary between the talooks of Nandyconda (just traversed) and that of Pákhál to the west.

Boundary between two Talooks.

A short distance beyond Lingoogoodium, there is a small hill of Kamthi sandstones round which a stream flows; after crossing this and another wider one, which may be the Kinnersammi, the path begins to ascend, and then crosses a low ridge of Vindhyan slates.

Kamthis cease near Lingoogoodium.

Vindhyans.

No more Kamthis are to be seen for 10 or 12 miles to the west; their general south-western edge trends northwards past the small hill west of Lingoogoodium.

The path now runs through a rather wilder country, still covered with tree, jungle, and coarse grass. The general elevation is about 1,000 feet above the sea, and the surface of the country is rather rugged with low ridges. It is impossible (unless clearings were made) to get a view anywhere to give one a fair idea of position. I got on one small hill which gave a view over a country of apparently endless tree jungle unbroken by any distinct feature, the long range of Vindhyans to the south-west of Goondala being only recognizable. Two or three paths cross this waste of jungle to Kámárum; that followed by me was reported to be the best. It is a mere track occasionally worn into two ruts by the wood-cutters' carts, and much intruded on by trees, so that my packages on the camel's back were much torn and rubbed. Otherwise, there are no difficulties or even dangers.†

Elevated and wild country.

To Kámárum.

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* The fragments of coal said to have been found at Arlapully, could not have come down from the Kámárum field, as there is a high water shed between the two places. Kámárum fragments might turn up above Mungumpett, on the Godavery.

† The route, as given in Colonel F. H. Scott's Route Book, is described as rather rugged and dangerous; but this description is of many years ago. However, it is not a path to be travelled during the night time.

Style of Vindhyans.

The rocks are generally reddish and brown earthy clay-slates and a few beds of quartzite sandstone of the Vindhyans, not at all unlike those of parts of the North Arcot and Cuddapah districts traversed by the north-west line of the Madras Railway.

Kámárum.

Kámárum, in the Pákhál talook, is a poor village* in the midst of about the wildest part of this jungle-covered region. It is supposed to be the nearest convenient village to the coal locality of the Pákhál talook.

Coal-field, north north-west of Kámárum.

Without further preface, it may as well be stated at once that this coal-field is very small and ill-placed in every way for its development.

At the most liberal calculation, it is 156 acres in extent, and it very possibly may yield 2,265,120 tons of coal, of which I should say 1,132,560 tons would be good coal, almost as good as that of the Warda R. coal-fields. It is unfortunately lying at the very inconvenient angle of 30° on the average; and the seams are apparently the water holders of the field.

Account of the discovery of coal-field.

This little coal-field was reported to the Nizam's Government by the then Tahsildar of Kandiconda, who gave a tolerably exact account of the occurrence of the coal and the nature of the country. There was great enthusiasm on the subject, and a reward of Rs. 2,000 was at once determined on; but it became doubtful as to whose the reward ought to be, the Tahsildar being supposed to have a great claim. He certainly made a rush at the field as soon as he heard of it, though it was not in his talooks. However, it has now been definitely settled that the reward goes to the Koi men who knew of the coal, and the Banya who got the information from the Kois, by making enquiry on the subject. Under such a fair adjudication of the reward, it may be that further information regarding other seams of coal in this region may now be volunteered.

No other coal near at hand.

So far, there is no more coal in the locality in question, it may be found lower down the valley of the Pungady Vágu, and, as stated above, there are fair signs of it at Mootapooram in the Kandiconda Talook, while the Barakars may crop out among the hills due north of Lingoogoodium.

Position of coal-field.

The coal-field lies about six miles north north-west by west of Kámárum, in the bottom of a wide valley opening northwards, on a main feeder of the Pangady Vágu.

A small patch of Kamthis.

Rocks of the country mainly Vindhyans.

Leaving Kámárum, the path for about 3 miles goes along the plateau top of a spur extending into the valley, over a thin set of Kamthi sandstones and conglomerates which are resting nearly horizontally on Vindhyan slates. This covering of sandstones is only a thin outlier left on the older rocks, which, excepting at the coal-field, are the rocks of this part of the country. At the end of the spur, the path descends a low scarp or step of 30 or 40 feet, and then goes north-west for some distance down into the valley, until it crosses the main stream for the first time.

* Deserted, while I was there, the "Kois" having migrated to another group of huts not far off. As a rule, these people deserted every village we came to or passed by, but they gradually emerged from the jungle when they found that no harm was meant, and came up to the camp.

Here, the course of the stream is over dark green trappean rock (weathering into a mudstone) with dyke-like masses of compacter rock, occasionally laminated and bedded, which is soon seen to be of the Talchir series. True Talchir conglomerates and fine muds occur very shortly after this, especially throughout the course of the river beds, but they are mainly volcanic muds and ashes associated with a great boulder bed of irregular thickness. Higher up come fine dirty green-mud and sandy-mud shales, and then thick beds of fine pale greyish-green sands. The lowest rock seen within the neighbourhood of the river bed is of trappean matter, generally devoid of lamination, of a dark-green color, occasionally nearly black, weathering of a dark-brown or reddish-brown color, of a compact dull stony texture, weathering into a compact sand-stone. This, as well as some of the shales, is occasionally slightly vesicular, or finely tufaceous and containing small fragments of slate and shale. This lower deposit is in places somewhat conglomeratic, but I think the true conglomerate is higher in the series. Over this come a few thin laminated beds of the same style of rock, or as often an 'ash-like' mud-stone rock with large and isolated smoothed fragments of lime-stone, slate, quartzite, and occasionally gneiss and granite. Some of these fragments are very large, as from 4 to 6 feet by 2 and 3 feet, and they are generally lying singly in the finest form of this ash mud. At other times there are the more frequent seams of pebbles and shingle, though these are not crowded together as in an ordinary pebble or shingle bank.

Talchirs; trappean.

Talchir "boulder bed."

Lowest Talchirs, a form of trap.

Style of the "boulder bed."

This appears to be the representative of the usual 'boulder-bed' in the Talchir series: only in this region the new feature of its having been at times derived from volcanic sources, is I think clearly evidenced. As to the occurrence of the smoothed boulders in the fine mud, one can hardly lay aside the idea so often advanced by my colleagues, but that these were worn and deposited by glacial forces. Two large smoothed and rounded sub-angular masses of Vindhyan lime-stone certainly seemed to me to be scratched otherwise than as from the wear and tear of the river; but I had no means with me for heaving them out of their position to see if the uncovered sides were marked in the same way. It is fair to state that the few boulders of lime-stone (unscratched on their exposed surfaces) which I did displace, were not marked at all on their buried faces. An enthusiastic glacialist would certainly have seen in the Talchirs of this region, a deposit similar to that which is probably being laid down in the neighbourhood of Iceland, for instance, in the present day, where deposits of an undoubtedly volcanic source will be found associated with the debris of an ice-rubbed country.

Trappean and glacial.

The path crosses the river four times in a distance of about 3 miles, Talchirs being traversed all the time; but near the fifth crossing grey Barakar sandstones are met with on the slope of the valley descending again to the stream, and in the bed of the same there is a seam of thinly laminated shaly and stony coal of about 20 feet in thickness, dipping at 30° to 35° south-west by west.

Barakars with seams of coal.

The outcrop of the coal is seen very strong in the river bed as one goes northwards, and after a few yards the dip becomes a little easier. The river then makes a little bend by which the coal runs in under the bank, but beyond the bend it shows again in the river very strong, still with the dip of 30°—35° which, however, rapidly increases to 45° (if not really more beneath). It is about 18 feet thick, close to a narrow gully of the river crossed by a band of sandstones having a

Seam in the river bed.

north-west strike. Here the coal strikes into the land on the left bank; and nothing further is seen down the course of the stream, for a little more than a quarter of a mile of windings, but sandstones lower than the coal, and then beds of the Talchir series.

Three seams of coal lower down the stream.

Still following the stream, however, I found, at about 2,800 feet from the last gap, another sharply angular twist of the river crossing Barakar sandstones; and here the following section is traceable, in ascending order.

At the bottom: The boulder bed of Talchirs overlaid by dirty pale green fine muds, sandy muds, and thick beds of pale gray green fine sandstones. These are generally dipping westward or south-westward in irregular undulations, at 20° to 30°.

Resting unconformably on the fine sandstones are—

(1).	Grey weathering, slightly ferruginously noduled, very coarse, open textured, soft, pale, buff and white felspathic sandstones, with occasional thin layers of pebbles. Variously bedded, sometimes very thick, or thinning out over one another. The beds are somewhat thinner (3'—4') near the top, and more compact	74 feet.
(2).	Thinner flaggy beds of soft sandstone and dark grey or blue sandy micaceous shales	1—2 ft.
(3).	*Coal.*—Thinly laminated, rather stony, and full of patches of a soft velvety charcoal. (This is the seam showing in the bed of the stream higher up)	6 feet.
(4).	Coarse grey sands, thick and thin-bedded, somewhat thinner bedded towards top · at bottom, resting on the coal, a very thick bed, 20 feet or so, of coarse pale grey sandstones, with a few iron concretions	60 feet.
(5).	*Coal.*—(This is throughout the field a thin layer, and it at times thins out in strings into the sandstones).	6—12 inches.
(6).	Coarse sandstones same as those below last seam of coal	15 feet.
(7).	*Coal.*—Similar to lower seam	9 feet.
(8).	Thick beds of coarse grey sandstones	15 feet and upwards.

The upper bed of coal (7) shows in the steep face of the river banks; a fine bed, 6 feet of it exposed vertically, the dip being a little easier here (25°—30°). A little brook from the westward has hollowed back a small cave in the coal.

The middle thin seam (5) is just visible between cropping-up beds of sandstone.

The lower seam (3) is only visible immediately beneath a large cliff of the sandstones, at a sharp turn in the river, where the latter is crossed by a ridgy band of the sandstones below the coal, having a dip of 30° south-west.

The coal has been washed out, and the cleft thus formed is filled with gravel and sand, but the upper part of the seam can still be seen just under the cliff. This cleft is the water-holder of the place, and it is in like spots in the other sections exposed by the river in these coal rocks, that water is now standing.

A short distance further down the stream, the same three seams of coal may, with care, be traced out at different points; here the dip becomes rather easier, while the strike is tending more round to due west. South of this, for a mile or so, there is nothing but Talchirs, and hills of Vindhyans on either side of the valley.

Three seams throughout the field.

After a good deal of searching at the original locality, higher up the river, I found that the three seams of coal are also there, and they are apparently not much reduced or increased in thickness as a whole. The upper seam is possibly a few feet less, while the lower is as stated 20 feet thick. The beds associated with the coal are pretty much the same as those given in the section above.

Following the stream upwards from this for some 100 yards, round a spur on the right bank, there is another watering place under a ledge of sandstones; and here again is the lower seam of coal, still about 10 or 12 feet thick, overlying sandstones striking across the stream with a dip of 30° south-west. Coal visible in both banks.

Lastly, still higher up the stream, about 6 or 700 yards, a 6—12 inch seam is traceable in the vertical face of some low dipping sandstones on the left bank, at about 4 feet from the ground. This is very possibly the thinning out of the lower seam.

At any rate, not many yards higher up the stream, the Barakars cease altogether and Talchirs form the ground; but these ever extend only a few yards westward, when they are found to come up against Vindhyan quartzites of the main western hill-side of the valley.

8,000 feet of outcrop.

These three or four places down the course of the stream, showing from one to three seams of coal, thus indicate a curved line of outcrop of Barakars of about 8,000 feet in length; the Talchirs hading out to the eastward from underneath them.

Barakars overlaid by Kamthis.

All abut against main western ridge of Vindhyans.

Western boundary.

Breadth of field about 2,500 feet.

Examined at right angles to the strike, they are found in the hollow of this curved line to be overlaid by Kamthi sandstones forming a series of low ridges just behind that point of the stream where the coal was first found. The beds of these ridges, in their turn, dip at the high ridge forming the main western side of the valley. At either end of the outcrop, the coal rocks and the Talchirs are traceable into close proximity with the Vindhyans of the main ridge. The western boundary of this small field of Talchirs, Barakars and Kamthis is then, as nearly as possible, a north-west—south-east line joining the two ends of the curved outcrop; and the greatest cross-width of the area of Barakars and Kamthis is about 2,500 feet. The width of the Talchirs was not ascertained; it is possibly never more than a mile.

The western boundary abrupt, with a steep edge.

I was unable to find any of the upper rocks in contact with the Vindhyans to the westward; but it seemed that this boundary is either a faulted one with a nearly vertical edge, or preferably a natural one, the Kamthis, Barakars, and Talchirs having been deposited in a basin against a steep shore of Vindhyans.

General dip of coal rocks 30° westward.

The dip of the Kamthis in the minor ridges between the river and the main western range of the valley, is still at about 30° westward: so that we are perforce obliged to consider that the coal field throughout has about this average dip; except, perhaps, a little lower, at the northern end, where the beds are striking round west at the main ridge.

Section of thickest part of Kamthis and Barakars.

Continuing the section given above in ascending order, I was able, by going south-west at the main ridge, to roughly estimate that there are about 140 feet of Barakar sandstones over the upper seam of coal (possibly there may even be more seams than those now described) and then 950 feet of Kamthi sandstones.

To recapitulate in descending order:—

Kamthi sandstones ...		950 feet.
Barakars ...	Sandstones ...	140 „
	Coal ...	9 „
	Sandstones ...	15 „
	Coal ...	6—12 inches.
	Sandstones ...	60 feet.
	Coal ...	6 „
	Sandstones ...	74

Talchirs (thickness unascertained).

This is the thickest part of the Kamthis and Barakars together; the latter thin out to the south.

Area of Barakars about 156 acres.

Supposing that the western boundary has a nearly vertical edge, which I think is the true state of affairs, it may then, without allowing for greater area by the pocket-shaped form of the bottom, and the high dip, be considered that the area of Barakars is about the same as the area of the field in plan; and this is about 156 acres. I think I am very well within the mark by taking 12 feet or 4 yards as the average thickness of coal throughout the two seams together. There are about 4,840 tons in a square acre of coal, 1 yard in thickness; but only three-fourths of this can be got out in the working, so that we may calculate on 3,630 tons, which being multiplied by 156 for the area, and again by 4 for the thickness of coal, gives 2,265,120 tons of available coal. The coal, as described above, is about half shaly, and stony, the shaly being the best; so taking half this number of tons, it may be said that there are available in the Pángadi Vágú field 1,132,560 tons of fairly good coal.

Average thickness of coal may be taken at 12 feet.

Quantity of coal available.

Power of coal in an ordinary fire.

I could only judge of its powers by making ordinary fires (assays will be supplied from the Geological Survey Office by Mr. Tween). These were made before my tent of an evening; it was cold at the time (February) in this elevated region; and with merely a starting of a few sticks of wood, there was very soon a good blazing coal-fire which burnt with a brilliant flame for a long time. It then quieted down into a red-hot fire, with a pale low flame, lasting so for 2 or 3 hours; in the morning the fire was still in existence, but most of the burnt fragments still retained their general form in a heavy light-colored ash. For such a fire, 4 or 5 lumps of coal, each as big as an English brick, were used. The coal can be quarried in large lumps, which will bear rough carriage. The fragments used by me were just dug out from the bed of the river, where the coal must be much deteriorated from that unexposed to the atmosphere.

So far, the favorable aspect of the Pángadi Vágú coal has been given.

Disadvantages connected with the coal of this field, very great.

Dip high, and seams full of water.

Against it there is the extremely high dip, and the fact that as its outcrop is for the greater part of its length either in the river bed or close along-side—the only pools of water in the river being now on the seams—it is extremely probable that even in such an exceptionally dry season as this, the seams are full of water from outcrop to full depth. The area is very small and it is situated in the heart of an elevated and completely jungle-covered region, in which the number of villages, or rather small groups of huts, is extremely small and scattered. The only useful route for the coal to be drawn out is northwards by the valley to Salevoy or Mungumpett. In the present condition of the jungle, work could only be done from early in January to the end of May, as the country is reported to be either highly feverish, or rendered impassable owing to flooding by the rains during the rest of the year.

Area small, and situation very out of the way.

Unhealthy region.

Continuation of route from Kámárum westwards.

From Kámárum, the path continues still westward, first of all traversing the western range of Vindhyans, already referred to, by a cross valley, thickly grown with jungle, through which a clearing has lately been made; and so, across the rest of the Pákhál Talook to Hanamconda. Beyond the high ridge just crossed, there is a wide stretch of forest-covered, mostly high flat country with occasional shallow valleys and easy descents to other terraces of flat ground, until the more irregularly hilly country in which the great Pákhál tank is situated is reached. This country is all of Vindhyan rocks, mainly earthy slates with bands of quartzite, and one series of slightly magnesian grey silicious limestone having a dip of 5° to 10° south-eastward. The general lie of these Vindhyans is undulating, with a gentle dip to the eastwards: occasionally also high, and even vertical, strata occur, so that they hade up at times in low headlands to the westward.

Vindhyans, and their lie.

The Pákhál tank has been made by throwing a bund across a river, which has cut its way over this western outcrop, between two of these low headlands, and thus there is a noble sheet of water kept back among the few irregular hills bordering eastwards on the line of low headlands. It is a splendid tank: there was no rain to speak of last season, and yet now there is a beautiful and wide-spread sheet of water lying back in two arms on either side of a good big hill east-south-east of the bund: while from these are long bays reaching up behind low ridges of outcropping Vindhyans. On every side there is far-stretching jungle; even below the tank bund, for miles, there is the thickest and densest jungle, only broken here and there by a few patches of rice cultivation. There is not the population even in the country below the tank to make use of its waters; and no careful means are taken in these days of Mahommedan rule to conduct the water to a part of the country, where the population is more numerous. In the old Telingha times, when Warrungul was one of the great centres of the Telugu people, there must have been something more stirring in the way of human life than there is now in this desolate region of wide-spread jungle.

Pákhál tank.

Not more than a couple of miles below the tank, there is a great rectangular fort still standing entire as to its high mud and stone walls, but all overgrown with, and in the midst of, tall tree jungle. The Nizam's Government is at present erecting a large convict jail here, which not being yet ready for its prisoners, and with jungle around, looks almost as desolate as the old fort.

The coup-d'oeil of Pákhál tank is tame, the country being flattish and unbroken by any good hills, except the long low ranges far to the east near Kámárum, and the one large hill at the bank of the tank. In beauty and picturesqueness, it cannot for instance be compared with the great Cumbum tank in the Kurnool District.

The bund of the tank is very nearly on the western edge of the Vindhyans; in fact, the base of the low headlands at the south end of the bund is possibly made up of the bottom beds of the series, in this part of the country; for, about half a mile west of the bund, the stream of water from the sluice is crossed, and here there is very coarse granitoid gneiss of the crystalline series, and these are the rocks which make up the rest of the country westward to Hanamconda.

Western edge of Vindhyans.

Crystallines.

Note on Pákhál tank.—The tahsildar of Narsimpet has obligingly furnished me with the following data regarding this tank from records in his office: "The tank is said to have been constructed about sixteen hundred years ago by Rajah Khaldya. The bund of the tank is nearly 2,000 yards long, breadth 6,000 yards, and the depth back from the bund, 8,000 yards. When full of water, the depth at the sluice is 12 yards."

CAMP GUDDIGOODIUM,
1*st March* 1872.

WILLIAM KING,
Deputy Superintendent, Geological Survey of India.

SKETCH OF THE GEOLOGY OF ORISSA, *by* W. T. BLANFORD, A. R. S. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The province of Orissa consists, geologically as well as geographically, of two very distinct portions,—the one, a belt of nearly flat country from 15 to 40 miles in breadth, extending along the coast, and the other, an undulating area broken by ranges of hills in the interior. The former is entirely composed of alluvial formations, the greater portion of its surface being probably composed of deposits from the great river Mahanaddi and the smaller streams, the Bramini and Baitarni. Near its western limit alone, a few hills of gneissose rock rise from the alluvial plain, especially between the Bramini and Mahanaddi. The inland area, on the other hand, is chiefly composed of rocks of very ancient date, so completely altered and crystallized by metamorphic action, that all traces of their original structure are lost, and any organic remains which they may originally have contained obliterated. The same rocks cover an enormous area in Eastern and Southern India, and are usually spoken of in works on Indian Geology, as the Crystalline or Metamorphic series.

Further exploration in the little known Tributary Mehals will, doubtless, show the existence of beds belonging to other formations, but hitherto the only instance in which any considerable area is known to be occupied by rocks of later date than the metamorphics, is in the tract known as the Talchir Coal Field in the estates of Talchir, Ongúl, Bamda, Atmallik, Radakol and Denkanal. High up the Bramini, a series of very slightly altered or unaltered rocks, comprising slates with jasper, quartzite and schistose beds, are known to occur; but it has not been ascertained whether they extend into the district administered from Katák, though they are believed to occupy portions of Keunjúr and Bonai.

The greater portion of the Tributary Mehals has never been explored geologically, and the information procurable as to their character is most imperfect. It is possible that other coal fields may exist, though not probable. Even the Talchir Coal Field has only received, for the most part, a very hurried examination.

Excluding the formations of which no accurate information has been obtained, such as the slates, quartzites and jasper, believed to occur in Keunjúr and Bonai, the following is a list, in descending order, of the rock systems hitherto described as occurring in Orissa.

8. *Blown sand.*
7. *Alluvium.*
   b.—River Delta deposits.
   a.—Older alluvium of coast plain.
6. *Laterite.*
5. *Katák* or *Atgarh* sandstones.
4. *Mahadeva?* or *Panchet* sandstones and grits.
3. *Damúda* sandstones, shales, and coal.
2. *Talchir* sandstones, shales, silt, and boulder bed.
1. *Metamorphic* or crystalline rocks.

A brief description of the character of each of these formations, as found in Orissa, is appended.

1. Metamorphic or Crystalline Rocks.

These consist of various forms of gneiss, mica-schist, hornblende-schist, quartzite, &c. Crystalline limestone, common in many parts of India, has not been hitherto observed in Orissa. True granite occurs in the form of veins traversing the gneiss, and is of various forms, the most common being a highly crystalline variety with but little mica, and passing into Pegmatite of the kind known as graphic granite, beautiful specimens of which have been found in parts of the Tributary Mehals. This granite is apparently, for the most part, at least of contemporaneous age with the metamorphism of the gneiss. But, besides this, the gneiss itself frequently passes into a granitoid form perfectly undistinguishable in blocks from granite, but which, when in place, is usually found to retain every here and there traces of its original lamination, and to pass by insensible degrees into a distinctly laminated gneiss of the usual form.

Other prevalent forms are ordinary gneiss composed of quartz, felspar, and mica; hornblendic gneiss in which the mica is replaced by hornblende; the latter mineral sometimes forming a very large proportion of the rock, and quartzose gneiss, in which the felspar and mica or hornblende, are in very small proportion and the quartz predominates. This gradually passes into quartzite: a massive rock in general, in which felspar and mica are either wanting or occur only in very small quantities.

The above may be considered the prevailing forms of the crystalline rocks; but there are others of less frequent occurrence. Amongst these are diorite, amphibolite, syenite and a magnesian rock, a kind of pot-stone occasionally resembling serpentine. These may all, very possibly, be of later date than the mass of the metamorphics, though the serpentine-like pot-stone appears to be fairly intercalated.

2. Talchir Group.

The lowest beds associated with the coal-bearing strata are themselves destitute of useful fuel, and well distinguished mineralogically from the Damúda or coal-bearing rocks. They were first separated from the overlying beds in Orissa, and were named after the estate in which they were found. They consist, in the Talchir Coal Field, of blue nodular shale, fine buff or greenish sandstone, and of extremely fine silt beds, often interstratified with sandstone more or less coarse in texture, in thin alternating laminæ. The sandstones often contain felspar grains which are usually undecomposed. In the sandstone and fine silty shale, rounded pebbles and boulders of granite, gneiss, and other crystalline rocks frequently abound, some of them as much as four or five feet in diameter. This remarkable formation is known as the 'boulder bed,' it is peculiar to the Talchir group, and has been found in India wherever that group has been examined; in the valleys of the Damuda, the Sone, the Narbadda, and the Godavari, as well as in that of the Bramini.

Of this singular association of large blocks of stone in a fine matrix, but few other instances are known, the most remarkable one being that of the 'boulder clay' of Great Britain and other countries, which is now by most geologists considered to be of glacial origin. The boulder bed of the Talchir group differs entirely from the boulder clay however; in the former, the fine matrix is distinctly stratified, and the boulders are rounded, neither of which is the usual condition of the boulder clay. But the origin of such a rock is, in both instances, surrounded by the same difficulty, *viz*, that any current of water which could round and transport the boulders would sweep away, instead of depositing, the fine sand, clay, and silt in which they are imbedded. Yet nothing is clearer than that the two were deposited together. Ice is rather a startling power to invoke in endeavoring to explain the phenomena of rocks found in a tropical climate, but without its agency it appears difficult, in the present state of geological knowledge, to account for the Talchir boulder bed.*

3. DAMUDA GROUP.

Above the Talchirs, or occasionally resting upon the metamorphic rocks without the intervention of any other sedimentary beds, are found a series of sandstones and shales, with beds of coal. The sandstones are mostly coarse grey, and brown rocks passing into grits. They are usually more or less felspathic; the felspar being decomposed and converted into clay, and they are often ferruginous. Blue and carbonaceous shales, often more or less micaceous, and ferruginous shaley sandstones are characteristic of this group. Fossil plants, chiefly consisting of Ferns (such as *Glossopteris, Pecopteris*) *Trizygia, Equisetaceæ* and *Calamites*, and above all peculiar stems divided into segments, believed to be roots of unknown affinities (*Vertebraria*), are frequently found. Most of the fossil species found, perhaps all, are characteristic of the Damuda formation.

The peculiar interest attaching to this group of rocks is, however, derived from its being the only one in which workable coal has been found in the peninsula of India. All the coals of Raniganj, and the other fields of the Damúda valley, all those of the Narbadda valley, and of other parts of the Central Provinces, are in Damúda rocks. So far as they have hitherto been examined, the coals of Talchir appear to be of inferior quality to those of Raniganj, the Narbadda and some other localities, but the field in the Tributary Mehals has, by no means, been thoroughly explored as yet.

4. MAHADEVA? GROUP.

Above the coal-bearing series in the western part of the Talchir coal field, there is found a considerable thickness of coarse sandstones, grits and conglomerates, quite different in character from the beds of the Talchir and Damúda groups, and resting unconformably upon them. These rocks are usually coloured of various shades of brown, they are frequently very ferruginous, and the separate beds composing them are massive and not interrupted, as the Damúda sandstones frequently are, by partings of shale. They form hills of considerable size in Radakol.

It is by no means clear that these beds are the representatives of the group in the Narbadda valley to which the name Mahadeva was first applied, but there is a general sub-division of the rocks throughout the greater portion of the Indian coal fields into three principal groups. To the higher of these the term Mahadeva has been given in the Narbadda valley and in Orissa, and Panchet in Bengal, and until re-examination of the Orissa beds has enabled their relations to that of other coal fields to be more accurately made out than was possible when they were first mapped, it appears best to retain the name then applied to them.

* In 1855 Mr. Blanford suggested (Memoirs, Geological Survey, India, i, p. 49) that these beds might have been deposited on a high table land, and that the association of the boulders was perhaps due to ground ice. The advance of cosmical theories since that time has rather tended to increase the possibility of periods of cold having occurred in the course of the earth's history, some of which may have been sufficiently severe to affect the tropics, or portions of them. The Talchirs have now been found over so extensive an area that the probability of their having been deposited at any considerable elevation above the sea has greatly diminished, and some observers are inclined to consider them marine, a view which I do not share, but at the same time no other hypothesis, not involving ice action, has been offered which accounts satisfactorily for their peculiarities. (Since this was written strong confirmation of Mr. Blanford's views has been obtained, by finding in these Talchir boulder beds masses of granite of large size, the surfaces of which have been polished, scored, and furrowed precisely as are the masses of rocks or boulders, found inbedded in, and transported by, ice-floes or glaciers. T. OLDHAM).

5. Katák (Cuttack) or Atgarh Group.

South-west of the town of Katák is a considerable area occupied by grits, sandstones and conglomerates, with one or more beds of white or pinkish clay. The beds are very similar in general character to those last described, but there is no evidence of their connection, and it appears at least as probable that the Kátak rocks are of later date.

No fossils have been found in these beds except some obscure impressions apparently of vegetable origin in the clays.

6. Laterite.

The laterite of Orissa is evidently of detrital origin, and consists essentially of small pisolitic nodules, chiefly composed of hydrated oxide of iron (brown hæmatite) and coarse quartz sand, cemented together, more or less perfectly, into either a firm though somewhat vesicular rock, or a less coherent mass, or at times remaining in a loose gravelly condition, and thus passing by various gradations into a sandy clay with a few pisolitic iron nodules. As a rule, the forms containing most iron are the most coherent, and *vice versa.* The more solid forms are largely used as building stone, having the peculiar but important property of being softest when first cut and of hardening greatly on exposure.

Beneath the detrital laterite, especially when a felspathic form of the metamorphic rock occurs, the decomposed upper portions of the latter are frequently greatly impregnated with iron, and converted into a kind of lithomarge which closely resembles the detrital laterite in appearance, and is employed for the same purposes.

The massive form of laterite which caps many of the higher hills in Peninsular India, and which is more compact than the detrital laterite, is not known to occur in Orissa.

7. Alluvium.

a. Older Alluvium of the Coast Plain.

In the neighbourhood of the hills and frequently for many miles from their base, the alluvium of the plains consists of clay and sand, usually more or less commingled, and, in most places, containing calcareous concretions (kankar or gútin) and pisolitic ferruginous nodules. This deposit passes, as already mentioned, by insensible degrees into laterite on the one hand, and into the more recent delta alluvium on the other, but in its typical form, it is well distinguished from both by being more sandy and by containing nodular carbonate of lime or kankar.

The age of this alluvial deposit is shown by its surface having been modified and rendered uneven by the action of rain and streams; so that the country composed of it is more or less undulating.

Whether this formation, or any portion of it, is of marine origin is a question hitherto undetermined. So far as it has been yet examined, it appears in Orissa to be unfossiliferous. The greater portion has, doubtless, been produced by deposits washed down by streams and rivers from the higher country to the westward, and it appears probable that a portion of these have been deposited along the coast. But other deposits have been, in all probability, formed upon the original marine beds by the additional accumulations brought down by streams and washed by rain from the hills, so that it is questionable whether the lower marine beds, which probably exist, are anywhere exposed.

b. River delta deposits.

In the neighbourhood of the great rivers the soil is finer and the country level, the greater portion of it being yearly overflowed by flood waters and receiving a fresh deposit from them, except in places where they are kept from overflow by artificial means. The alluvium thus formed is generally highly fertile, but the country is swampy and often malarious. As above pointed out, the only character by which this modern alluvium can be distinguished is the flatness of its surface, showing that the area occupied by it is one of deposition and not of denudation. Usually also, it is less sandy than the older alluvium, and kankar is not of frequent occurrence in it, though a thin layer of it often covers deposits of calcareous sand and clays, from which the later deposit can, with difficulty, be distinguished.

8. Blown Sand.

Along the coast in places, as about Púrí, large tracts of ground are covered with sand blown inland from the beach. The nature and origin of the formation are obvious.

In proceeding to give a sketch of the geological characters of the different districts and states of which Orissa is composed, I shall first describe the districts of Balasor, Katák and Púrí, and subsequently those Tributary Mehals of which any definite information has been obtained.

1. Balasor.—Almost the whole district consists of alluvial deposits. Metamorphics occur in the Nilgiri hills, along the western boundary, but they scarcely enter the district anywhere, and in no case are found more than a mile or two within the boundary. Laterite, frequently massive, forms a narrow fringe to the hills in places, but not everywhere.

A few sand hills skirt the shore in the north-eastern part of the district, and on the east of the Súbanrika they extend for three or four miles inland.

The older alluvium occupies the greater portion of the district, the flat river alluvium forming the southern part near the Bytarni, Karswa and Bramini rivers, and a tract in the north-east near the Súbanrika. Around Balasor itself the soil is rather sandy, and contains laterite gravel. Concretionary carbonate of lime (kankar) is widely distributed, especially in the western parts of the district.

Katák.—As in Balasor, the largest part of the district consists of alluvium; the older form, with an undulating surface, occupying, however, a much smaller area proportionally, and being confined to the north-western part of the district; nearly all of the remainder being composed of the flat deltas of the Mahanaddi and Bramini. Along the sea coast blown sand generally occurs, but only forms a narrow belt.

Between the rivers Bramini and Mahanaddi in the Killas of Balrampúr, Madpúr, Darpan, Kalkala, Daljúra and scattered over the country to the east in Pargana Ulti, there are numerous hills all more or less isolated, and all composed of gneiss. Along the Bramini, near Balrampúr, and for some miles to the south-east, the rock is compact and granitoid. Further south it is less compact and usually soft from partial disintegration near the surface. It is marked with numerous red blotches, the remains of decomposed garnets. This soft decomposed gneiss is sometimes quarried and used for building. The hills in this part of the country are most inaccurately represented on the Revenue Survey maps.*

No laterite occurs around the more eastern hills, but around those in the neighbourhood of the road from Calcutta to Katák, there is frequently a narrow fringe, often conglomeratic,

* Those on the Topographical Survey maps of the Tributary Mehals, on the other hand, are very correctly drawn.

as if it had been originally a beach deposit, and to the west of the high road to Katák the metamorphic hills are surrounded in general by broad terrace-like flats, frequently stretching from hill to hill, and when they do not do so, affording evidence that the laterite is continued beneath the intervening alluvium. This laterite is frequently employed for building purposes.

PÚRI.—The southern district of Orissa is much smaller in size than either of the others, and yet the extent of hard rocks is larger than in either Katák or Balasúr. All the country near the coast and a broad tract in the north-east of the district are alluvial, but the western parts of the area are occupied by laterite, sandstone, and metamorphic rocks. There is a very small extent of the older undulating alluvium; almost all the eastern part of the district, and the country extending from the Mahanaddi to the Chilka lake is perfectly flat, and consists of the newer or delta alluvium. Hence its liability to flooding from the Mahanaddi. Hills of blown sand extend along the whole coast, and frequently are disposed in two or three principal ranges,—the first close to the shore, the second from one to two miles inland, and occasionally there is another still further from the sea.

The greater portion of Perganas Domipada and Dandimul, south-west of the town of Katák, consist of the Atgarh sandstone, composed, as already mentioned, of coarse sandstones and conglomerates. To the west these beds appear to rest on the metamorphic rocks, and they have a general dip to the east and south-east, at low angles not exceeding 5° or 6°. They are surrounded on all sides by laterite and alluvium. At their apparent base to the west is a coarse conglomerate, the pebbles chiefly of quartzite.

These rocks contain one band at least of white clay, which is largely dug, and used for white-washing houses and for other purposes.

South-west of the sandstone country and west of Khúrda, there is a broad undulating plain, partly covered with laterite through which the gneiss rises at intervals. In the extreme west of the district around Bolgarh and Goriali, there are two very barren ranges of no great height, running east and west, and formed of compact, rather granitoid gneiss.

From this point, whence the boundary of the district turns to the eastward as far as the Chilka lake, only detached hills occur, all of gneiss, with intervening plains of laterite and alluvium. The group of hills near Chatarma are of granitoid gneiss, most of the others are of garnetiferous gneiss with quartzose bands. Such are Khúrda hill and the smaller rises in the neighbourhood, and also the hills east of the Katák and Ganjam road between Rameshwar and Monglajuri.

Precisely similar country extends to the west of the Chilka lake. The lake itself is a part of the sea first rendered shallow by deposits from the mouths of the Mahanaddi and from silt carried up the bay round the hills near Ganjam by the violent southerly winds of the monsoon, and then entirely cut off by a spit, formed, by the same agency, of sand drifted along the coast. Near the south-western extremity of this spit there is a considerable deposit of estuarine shells, at a height of 20 to 30 feet above the present flood level of the Chilka. The shells found, *Cytherea casta* and *Arca granosa*, have not been observed living in the Chilka, and both are estuarine species, not occurring in the sea itself, but the former is now abundant in the estuary connecting the lake with the sea. This deposit appears to afford evidence of a recent elevation of the land.

There can be but little doubt that the Chilka is gradually diminishing in size and in depth, but as it receives no streams of importance, the quantity of water charged with sediment poured into it is small, and its rate of decrease is probably very slow. Its fauna is peculiar, and deserves more attention than it has hitherto received. Indeed, the whole estuarine fauna of the Indian backwaters and deltas has been but imperfectly worked out, and further information is extremely desirable, of the mollusca above all, for the illustration of the fossils of the many deposits which have doubtless accumulated under very similar circumstances in past times.

Tributary Mehals.

Of the geology of the following states:—

Moharbanj.	Bodamba.
Pal Lahara.	Tigerea.
Nursingpur.	

lying north of the Mahanaddi, and of all the states south of the Mahanaddi river, except Banki, *viz.*:—

Boad.	Nyagarh.
Daspala.	Kanapúr.
Kandapada.	

nothing whatever, definite, is known.

It is pretty certain that a large proportion of their area consists of metamorphic rocks, and it is possible that no others may be found.

Of Keunjúr and Nilgiri, only the edges bordering on the Balasor district have been examined. Hurdole has been traversed, portions of Denkinal and Atmallik have been examined, whilst of Ongúl, Talchir and the little estates of Atgarh and Banki, a somewhat more general survey has been made, still however far from complete or detailed.

Nilgiri and Keunjúr.—The hills bordering on Balasor consist entirely of metamorphic rocks of various kinds. In the northern part of the range gneiss is found, so granitic that the direction of the foliation can scarcely be ascertained. It appears to be nearly parallel with the escarpment of the range.

Granite veins are scarce, but green-stone dykes or pseudo dykes, many of them of great size, abound, and most of them, if not all, appear to be parallel with the gneissic foliation. This fact renders it probable that the dykes in question are really beds so altered as to be perfectly crystalline.

A kind of magnesian rocks, intermediate in composition between potstone and serpentine, approaching the former in appearance but less greasy in texture, is quarried to some extent chiefly for the manufacture of stone dishes, plates and bowls. These stones are roughly cut into shape in the quarry, and finished partly with tools, partly on a lathe in the villages. The rock employed occurs, interfoliated with the gneiss, in several places, and is quarried at the villages of Santragodia and Gujadiha, a few miles south of Nilgiri, at a spot two or three miles from Júgjúri, and in scattered localities to the north-west.

A few miles west-south-west of Júgjúri, near Parkpada, the granitoid rocks are replaced by a tough, hard, indistinctly crystalline, hornblendic rock resembling diorite, but exhibiting more foliation than is seen in the hills near Nilgiri. Still further to the south-west, quartz schist comes in, well foliated, occasionally containing talc. A detached hill near Bakipúr consists of this rock, and so does the whole south-west portion of the range as far as Rugadi, except in the immediate neighbourhood of the Salandi Naddi, where it leaves the hills. Here syenite occurs, and the same forms a detached hill near Darapúr. The south-western portion of the range is free from the trap dykes, which are so conspicuous in the north-east of Júgjúri.

All the western portions of Keunjúr are unexplored.

TÁLCHÍR, ONGÚL, and ATMALLIK.—*The Tálchír Coal-field.*—These states comprise by far the most interesting geological area in Orissa and its dependencies. The basin of sedimentary rocks known as the Tálchír coal-field is surrounded on all sides by metamorphics. This basin extends about 70 miles from west by north to east by south, with a general breadth of from 15 to 20 miles, its eastern extremity at Karakprasad on the Bramini river being nearly 50 miles north-west of Katák town. Its western limit is not far from Rámpúr in the state Rádákol, and it comprises nearly the whole of Tálchír and a considerable portion of Ongúl and Rádákol, with smaller parts of Bamda, Atmallik, and Denkinal.

The western half of this field, or more than half, is chiefly occupied by the rocks already described as belonging to the Máhádévá group;* conglomerates and coarse sandstones, which form hills of considerable height in a very wild, jungly, and thinly inhabited country. It is by no means improbable that the Damúda coal-bearing rocks will hereafter be found in portions of this area. Indeed, they have been observed at the village of Patrapada.

In the extreme west of the field Tálchír beds occur in the upper part of a valley tributary to the Tikaria near Deincha, and also near the village of Rámpúr in Rádákol. In both cases Máhádévá rocks appear to rest directly on them without the intervention of any Damúdas.

Besides occupying the western part of the field, the Máhádévás are found in two places along the northern boundary, which is formed by a fault of considerable dimensions. One of these places is near the villages of Bodaberna and Dereng, where the upper beds occur as a narrow belt five or six miles from east to west, their presence being marked by low hills of a hard conglomerate. Farther to the west, they recur in another isolated patch forming the rise called Konjiri hill and its neighbourhood. This hill consists of sandstone capped by conglomerate, the pebbles from which weather out and cover the sides of the hill, concealing the sandstone beneath.

The northern part of the field on which these outliers of the Máhádévás occur is much cut up by faults, or, to speak more correctly, by branches of one great fault. These faults are in some places marked by a quartzose breccia, containing fragments of sandstone and other rocks. The vein of breccia varies in breadth; at the village of Kerjang, it is so largely developed that it forms a hill of considerable height. Between the branches of the fault Tálchír beds and metamorphics occur; north of all the faults metamorphics only are found.

The eastern part of the field from near Kerjang on the Tikaria river and Koukuraí on the Tengria to east of the Bramini is principally composed of Damúda rocks. These may usually be recognised by the occasional occurrence of blue and black shales, the latter carbonaceous and sometimes containing coal. The general section of the beds, so far as could be made out in a difficult country much obscured by surface clays and jungle, is as follows:—

1.—Interstratifications of blue and black shale, often very micaceous, with ironstone and coarse felspathic sandstone. These are at least 1,500 feet thick.

2.—Carbonaceous shale and coal, about 150 feet.

3.—Shales and coarse sandstones, the latter prevailing towards the base; thickness doubtful, but not less than 100 feet.

* At the period when the Tálchír coal-field was examined, nothing whatever was known of the classification of rocks which has since been made out by the Geological Survey in the various coal-fields of India. Indeed, one of the very first and most important distinctions, that of the Tálchír group below the coal-bearing division, was made in this region, as already mentioned. The boundaries of the Máhádévás and Damúdas on the map in the Memoirs, Geological Survey of India is merely a rough approximation made from memory after quitting the field. The differences of the rocks had been noted in the field, but their area had not been mapped.

If this be correct, the coal only occurs upon one horizon. It is by no means impossible, however, that other beds may be found.

Coal is known to be exposed in three places. The most westwardly of these is at Patrapada in Ongúl, a village on the Medúlia Jor, a tributary of the Ouli river. Here some six feet of carbonaceous shale and coal are seen in the bank of the stream, capped by clay, upon which rest the coarse grits of the Máhádévá group. The area occupied by the beds is small.

The next place, which is far better known, is at Gopalprasad in Tálchír, on the Tengria river. The rocks at this spot are nearly horizontal for a long distance, and the coal bed extends for some miles along the banks of the stream above the village. It also recurs lower down the stream. The thickness of the bed is considerable, but its quality inferior, the greater portion being excessively shaley and impure. Selected specimens contain upwards of 30 per cent. of ash. It by no means follows, however, that better coal may not be found, and even the inferior fuel would be useful for many purposes if any local demand existed, and from the horizontality of the bed a large quantity might be procured with very little labour. The general dip in the neighbourhood is to the north, and any attempts at working the coal on a large scale, or further exploration by boring, should be made north of the Tengria stream.

The third locality is in a small nalla running into the Bramini from the west just north of the town of Tálchír. Beds lower than the coal are seen in the bank of the Bramini at the Rajah's residence; the carbonaceous shale with coal is exposed about 400 yards from the river in the small watercourse; only two or three feet are visible, the dip is north-west, and the coal is covered by micaceous, sandy and shaley beds. A boring north-west of this spot would test the bed fairly.

There is another locality in which, if the section can be trusted, beds just above the coal shales in position are exposed at the surface, and where, consequently, a boring might very possibly penetrate them. This is at the village of Konkurapal in Ongúl.* It is by no means certain that the Gopalprasad shales are close to the surface here, but the spot is the summit of an anticlinal, and some black shale seen in the stream resembles the uppermost portion of the rocks of Gopalprasad.

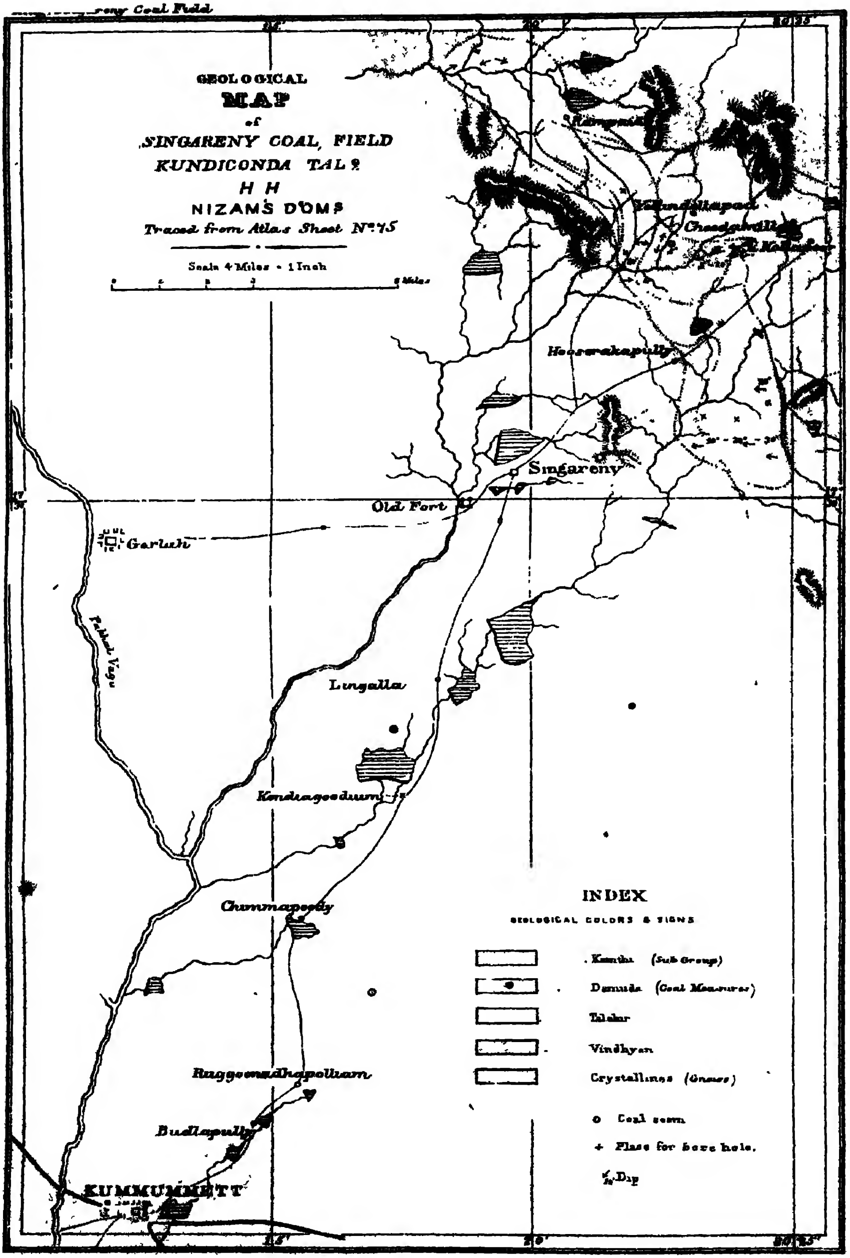
It is highly probable that closer search will show other places where coal is exposed at the surface.

The south-eastern part of the field consists of Tálchír beds, in which boulders are only occasionally found towards the base. They are numerous near the village of Porongo. Above the silt bed containing the boulders, there is a fine sandstone frequently containing grains of undecomposed felspar. There is no chance of coal being found in this portion of the basin, that is, south of a line drawn from east by north to west by south running about two miles south of Tálchír.

In several places in the Tálchír field iron is worked. The ore varies; sometimes the ironstones of the Damúda beds are used, but more frequently surface concretions, the supply of which is necessarily limited; sometimes the little pisolitic nodules of the laterite are found washed from their matrix and deposited in sufficient quantities in alluvial formations to be worth collecting. In one instance noticed, the ore was derived from the metamorphic rocks

* Not *near* Ongúl (that is, not near the town so called,) as misprinted in Memoirs, Geological Survey of India, I, p. 61. The village is about 10 miles north-west of Gopalprasad.

Note.—The foregoing sketch of the Geology of Orissa was prepared for use in the proposed general Gazetteer of India, now in course of preparation, under the direction of W. W. Hunter, LL. D.


GEOLOGICAL
MAP
of
SINGARENY COAL FIELD
KUNDICONDA TAL?
H H
NIZAM'S D'OM?
Traced from Atlas Sheet No. 75
Scale 4 Miles = 1 Inch
Singareny
Old Fort
Garlah
Heesrakapully
Lingalla
Kondragoodum
Chummapoody
Raggoonadhapollam
Budlapully
KUMMUMMETT
Pakhal Vagu
INDEX
GEOLOGICAL COLORS & SIGNS
Kamthi (Sub Group)
Damuda (Coal Measures)
Talchir
Vindhyan
Crystallines (Gneiss)
Coal seam
Place for bore hole.
Dip

and brought from a distant locality; it resembled the mixture of peroxide of iron and quartz found at the outcrop of metallic lodes and known as 'Gossan' in Cornwall. The method of smelting the iron in small furnaces is similar to that used in other parts of India, but the bellows employed are worked with the foot, a peculiarity only found in the south-western dependencies of Bengal and in Orissa. An account of the process with figures by my brother, Mr. H. F. Blanford, will be found in Dr. Percy's Metallurgy of Iron and Steel, p. 261.

The arenaceous ironstones of the Damúda group would, doubtless, yield a large supply of ore.

DENKINAL and HINDOLE.—These require scarcely any notice. So far as is known, they consist of metamorphic rocks, except the western extremity of the first named State which comprised the eastern end of the Tálchír basin. The metamorphic rocks are of the usual descriptions.

ATGARH.—The northern and western parts of this State consist of metamorphic rocks. Along the Mahanaddi from near Katák to the boundary of the state within three or four miles of the village of Tigoria, there is a belt four or five miles broad of the same "Katák" sandstones as are seen south of the Mahanaddi in the Púri district, being in fact a portion of the same basin. The rocks are precisely similar—coarse sandstones and conglomerates with one or more bands of white clay.

BANKI.—West of the sandstone area in the Púri district there is a broad expanse of alluvium running for a considerable distance to the southward from the Mahanaddi; west of this again metamorphic rocks occur. There is a fine semicircle of detached hills running from Bankigarh to the village of Bydesar. The hills are partly of garnetiferous gneiss, partly of compact hornblendic gneiss. Banki Peak is of very quartzose gneiss. The strike varies in a peculiar manner, being very irregular, but with a general tendency in all the hills to dip towards the centre of the semicircle. South of the hills is a large undulating plain partly covered with laterite.

W. T. BLANFORD.

NOTES ON A NEW COAL-FIELD IN THE SOUTH-EASTERN PART OF THE HYDRABAD (DECCAN) TERRITORY, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

In the regular course of my work I have found a further small and hitherto unknown outlier of coal-bearing rocks, some thirty miles south-east of the Kamáram or Pangady Vagu field already described in these records.*

The present field is situated between about 17° 30′—17° 40′ north latitude, and 80° 18′—80° 25′ east longitude, near the villages of Rumpaid, Yellindallapad,† Hooserakapully, and Ragabonagoodium, in the eastern part of the Kundyconda talook. Its southern extremity is about four or five miles east of the large village of Singareny, and it may be as well to give this name to the field.

It is a narrow irregular patch of the 'plant-bearing series' of rocks, about eleven miles long and from one to two miles in width, giving an area of about nineteen square miles, though at the same time the coal measures are only supposably about eight square miles in extent.

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* Records, Geological Survey of India, Vol. V, Part 2, p. 46.

† Yellindallapad is nearest to the outcrop of coal seam; but it is deserted at present (March 1872). Kollapoor and Cheedamulla (Sodamills), a couple of miles to the east, are larger villages.

As the crow flies, it is about twenty-three miles north-north-east of the town of Khummumet,* and thirty-six miles east of Nellycudr, the tahsil village of Kundyconda talook.

As far as my knowledge goes, coal is only visible at one spot, and it is possibly only due to the fact of the country being so dried up this year, and the exceptional lowness of the water in the few stream pools, that I was able at last, after long and apparently hopeless searching, to find the upper edge of a seam showing just above the mud and water in one of these pools.† For this reason also is accountable the fact, that the people around had no idea of the existence of coal.

Even though the seam had not eventually been met with, I should have announced this as a possible coal-field, and recommended that it should be proved by boring, for the rocks were to my mind clearly of the coal-bearing series.

I am unable to give now the thickness of the seam, for neither time nor means for excavation were at my disposal; but there are two feet of coal ascertainable, and it looks a good strong decided seam.

The coal, so far, is tolerably light, compact, charged slightly with patches of powdery charcoal, is more or less bright, and breaks with a sub-conchoidal fracture. In an open fire, after being well dried in the sun, it burns brightly, though not quite so brightly as that of the Pangady Vagu field, and leaves a soft powdery ash.‡ A fair average specimen gives the following assay—

Fixed carbon	62·4
Volatile matter (Moisture 6·0).	22·6
Ash	15·0
	100·0

The specimen is however only from a few inches within the exposed surface of the seam.

Owing to the absence, or concealed state, of the outcrops of coal it is utterly impossible as yet to say what its extent may be, and this cannot be ascertained until borings have been put down in various parts of the field. The positions of the different series of rocks can only be indicated, as also the fact that there is coal.

A small map§ is appended, showing the general outline of the field and the rock series. Absolute correctness of boundary could not be attempted in this map; but the lines will be found sufficiently correct for future exploration.

This is essentially a field requiring examination by borings, which may be put down at some of the spots which are suggested on the map. In the Pangady Vagu field the outcrop of coal is so freely exposed that 'he who runs may read' it; but here, in the Singareny field, the mineral wealth is not at all so evident, though if it exist in any quantity, which I am inclined to think it does, it is to be got at and carried out infinitely easier in every way than at the Pangady Vagu.

* This name has been variously given, but the above seems the nearest adaptation to کہم مث which is the official manner of spelling it. It is distinctly not *Kumarmet*, the spelling in the atlas map is very fair.

† It is possible therefore that the seam may not be visible to future explorers; but I showed it to two of the people of Kollapoor, who can easily point out the spot.

‡ In this, very different to the Pangady Vagu coal, the ash of which is hard and retains the form of the original fragments.

§ The southern extremity of the field is left undefined, as I am not quite sure that it does not extend further south. Lateness of the season and absence of water prevented my continuing the survey among the low hills in this direction.

Here, there is no hilly country to be got over, the locality being in the low country; while there is not nearly such thick jungle, though the field is completely covered by thin tree forest. The villages are somewhat more frequent and populous, and there are well marked paths in several directions. The distances also to the coal from Khummumet and Kundyconda are trifling when viewed in connexion with the proposed branch line* of Railway from Warrungul south-eastwards to the confines of the British Territory.

It is difficult to indicate the exact place of the coal outcrop, owing to the inability of obtaining a sight at any place through the jungle: but it is about two miles, or scarcely this, due west of the small hill station marked on the atlas Sheet 75, near the villages of Cheedamulla (Sodamilla) and Kollapoor, in the bed of the Yellindallapad vagu or stream. At this place, the stream is crossed by two low barriers of thick bedded sandstone striking nearly east to west with a dip of about 5° to the south, though the more northerly of the two barriers is part of a low anticlinal with the beds on its northern edge dipping north. The stream has cut an irregular zig-zag course, partly pot-hole and part gully, across this latter barrier, with rudely vertical sides of from four to thirteen feet high. The gully is deepest in the middle, deeper than at either the entrance or exit, and here the sandstones have been scoured out sufficiently to leave the top of the coal seam exposed all round the edges of an oblong pool, the floor of which is also of coal. It is thus that the thickness of the coal cannot be ascertained without boring or sinking a pit.

About two feet of coal are visible, and the seam is overlaid by, at the deepest part of the gully, thirteen feet of sandstone in one bed. There is no passage by shales, or clays, from coal to massive sandstone above, the junction between the two being perfectly clear and sharp. The rock is a coarse friable felspathic sandstone with small quartz pebbles, or gravel of pebbles thinly distributed through it. At the thickest, there is a single bed, but this eventually resolves itself into two or three thinner beds. This is the character of these sandstones on the Pangady Vagu as well as here; that they do not run of an even thickness for any distance, but that there are as it were bands of irregular lenticular beds of sandstone running into one another.

The general lie of the DÁMÚDÁ beds, as well as of the other associated rocks, is in easy undulations and from east to west, with somewhat of a general basin form; but they appear to be only exposed to any extent on the Yellindallapad Vagu. Over the rest of the field, if they exist, they are covered by sandstones of the *Kamthi* sub-group, though seldom to any great depth, possibly not exceeding two hundred feet at the most in the southern part of the field. In the northern half of the field, it does not appear as if any boring would have to exceed one hundred feet.

The rock series exposed in this Singareny field are, in descending order:—

Kamthi, sub-group.
DÁMÚDÁS (coal measures).
TALCHIRS.
VINDHYANS.
CRYSTALLINES (Gneiss, &c.).

Kamthis and DÁMÚDÁS rest directly on the GNEISS for a good part of the eastern edge of the field. No TALCHIRS are seen here, nor do I think they exist. Round the rest of the field, except for a mile or so to the east of Singareny, the underlying rocks are VINDHYAN.

* Part of a system of railway proposed by Mr. T. M. Hardy Johnston, M. Inst. C. E., Secretary to His Highness the Nizam's D. P. W., in a Memo. addressed to Sir Salar Jung Bahadur, G. C. S. I., dated July 1871.

The TALCHIRS are peculiar in occupying only the northern part of the field about Rumpaid, in the basin of whose main stream they are well seen forming good wide spreads of fine dirty yellowish green-grey (doe-skin-glove colored) mud sandstones. There are no signs of volcanic associations here, as is the case on the Pangady Vagu; nor is there any well-developed boulder bed. Here and there are occasional large pebbles or small assemblages of such; and in one spot in the bed of the stream from Mankarum, &c., which is joined by the Rumpaid stream, there is a huge block (now broken in half) of from 10 to 15 feet in diameter of VINDHYAN quartzite, which seems to be still almost *in situ*.

The TALCHIRS are distinctly overlapped by the next higher or coal-bearing series, and to such an extent both here and in the valley of the Godavery, that the two series would appear to be separated by a greater interval than mere unconformity of overlap would indicate. Otherwise, it is extremely difficult to my mind to account for such widely separated patches of a formation which always exhibits great uniformity of color and materials.

In the present field, I was not fortunate enough to find a section showing contact between the two series, but in my notes referring to the Pangady field the fact of unconformity is there stated. In that section, though a small one, the bottom sands of the BARAKARS are lying on bluntly-bevilled edges of mud sands of the TALCHIRS: the difference of angle being very little it is true, but there is still a difference.

It is to be remembered that the worn edges of the TALCHIRS (even now soft and friable mud-sands) would very likely, prior to the deposition of the BARAKARS, not be sharp and well defined, but rounded and somewhat fringed down; and the angle of dip not being much different from that of the newer rocks, their felspathic sandstones would, in general, lie over the sandy mud-stones more in the style of oblique lamination; and this is really somewhat the manner of the Pangady Vagu section, though there is, as I have written, the difference in lie of the *beds* themselves.

The DÁMÚDÁS and *Kamthis* are of the usual kinds, *viz.*:—coarse and fine felspathic sandstones, the *Kamthis* being coarser, more open textured, more ferruginous, and perhaps more gravelly. It is difficult, in the absence of any fossil evidence and favorable sections to draw any well defined boundary between these two series, though in general facies they are as distinct as possible, while at the same time they appear to be very distinct in age. It seemed to me that the passage between the two is marked by a set of thinner and somewhat closer-grained and compacter-brown sandstones coated on the surface with brown peroxide of iron, and that these are the lower beds of the *Kamthis*. On such a view, I have entered the two series in the accompanying map.

The hill station already referred to is of *Kamthis*; though, on the eastern side, and for some distance on the north and south, the base of the hill is of CRYSTALLINES. On the western side, one descends from coarse sandstones having a dip of about 10° west by north gradually to what are unmistakeable BARAKARS, but whether these are continuous right under the hill between the *Kamthis* and GNEISS, it is as yet impossible to say owing to the talus of debris all round.

From the hill there is a general easy undulation of BARAKAR sandstones nearly to the crossing of the Yellindallapad Vagu by the path from Singareny to the latter village; but just to the east of this path there are some low ridges of the compact ferruginous sandstones, which I take to be lower *Kamthis*. These are lying in a set of narrow undulations with a north—south strike; and at the crossing of the stream or *vagu* they are dipping east-south-east at from 20° to 30°.

The stratigraphic relations between the *Kamthis* and DÁMÚDÁS in this part of the country are also indicative of the latter being distinctly overlapped by the former; and that the DÁMÚDÁS were either only deposited in small detached areas, or were largely denuded prior to the deposition of the *Kamthis.*

In the present case the beds of the hill station do not seem to be underlaid for the whole of this floor, but to have overlapped the DÁMÚDÁS to the eastward; and on this account it is to be feared that the *coal measures* will not be found constant throughout the field.

There are two other small outlying hill masses of *Kamthis*, a few miles to the north-east of the Singareny field, which are in general character exactly like the hill station, or of a steep-sided plateau form, and made up of nearly horizontal beds. One of these is above or immediately north of Dharmapooram; and the second further north-east between Kamaram and Anantarum. A couple of miles further east, is the south-western edge of the main area of *Kamthis*. Now, there are no signs of DÁMÚDÁS under this south-west edge; nor are there any under the second of the two outliers mentioned. There are, however, grey and pale buff sandstones at Dharmapooram underlying the hill of Kamthis, possibly Dámúdás, though I saw no trace of coal; and it might be as well to examine these rocks by boring.*

In the southern part of the field, the *Kamthis* are very strong, particularly on the eastern edge after the stream from the Kollapoor tank is crossed. Here they form some low ridges, and have a dip of 20° or 30° westward. The country is, however, so covered up by clay and sandy deposits and jungle that it is difficult to make out the lie from these ridges to the western edges of the field opposite Singareny; or to tell if any undulation brings DÁMÚDÁ beds up to within easy reach of the surface. Some of the beds on the western edge opposite Singareny in the valley of the stream from Kollapoor, &c., seemed to be DÁMÚDÁ sandstones. Borings should be put down right across this part of the field, and certainly; below the eastern slopes of the ridges on the eastern edge.

I have indicated in the map where it would be advisable to put down bore holes. In no case does it appear as if these would ever need to be sunk more than 200 feet at the utmost, and most of them, particularly in the middle of the field, would seldom exceed 50 feet. In all cases the borings ought to be sent down to the gneiss (the greater part of the floor of the field is possibly of crystalline rocks), except in the neighbourhood of Rumpaid, where Talchirs will be met with; or to the Vindhyans (hard quartzite, slates, and siliceous limestones) northwards from the Yellindallapad stream, or in the southern end of the field.

CAMP KHUMMUMET, 30*th March* 1872. — WILLIAM KING.

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* The Geological Survey of India have no means of boring.

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BRETSCHNEIDER, E.—On the knowledge possessed by the ancient Chinese of the Arabs and Arabian Colonies and other Western Colonies, (1871,) 8vo., London.

COCCHI IGINO.—Brevi Cenni sui Principali Instituti e Comitati Geologici e sul R. Comitato Geologico d' Italia, (1871,) 4to., Firenze.
GEOLOGICAL SOCIETY OF ITALY.

HELLAND AMUND.—Ertsforekomster i Sœndhordland og graa Karmeœn, (1871,) 8vo., Christiania. ROYAL UNIVERSITY OF CHRISTIANIA.

HUNTER, W. W.—Guide to the Orthography of Indian Proper names, with a list showing the true spelling of all post towns and villages in India, (1871,) flsc., Calcutta. GOVERNMENT OF INDIA.

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KJERULF, PROF. TH.—Om Skuringsmœrker, Glacialformationen og Terrasser, (1871,) 4to., Christiania.

„ „ Om Trondhjems Stifts Geologi, (1871,) 8vo., Christiania.
ROYAL UNIVERSITY OF CHRISTIANIA.

„ „ Undersœgelsc af nogle Kulslags og Torv., (1870,) 8vo., Christiania.
ROYAL UNIVERSITY OF CHRISTIANA.

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Annals and Magazine of Natural History, 4th Series, Vol. VIII, No. 48, (1871,) 8vo., London.

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Indian Economist, with Agricultural Gazette and Statistical Reporter, Vol. III, Nos. 6 and 7, (1872,) 4to., Bombay. GOVERNMENT OF INDIA.

LEONHARD, G. UND GEINITZ, H. B.—Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Jahrgang, 1871, Heft VIII, (1871,) 8vo., Stuttgart.

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List of Civil Officers holding gazetted appointments under the Government of India, as it stood on the 1st July 1871, (1872,) 8vo., Calcutta.

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" " Geographische Mittheilungen, Supplement, No. 30, Australien in 1871, (1871,) 4to., Gotha.

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" Blanford, H. F.—Report of the Meteorological Reporter to the Government of Bengal, 1870, (1871), flsc., Calcutta.

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RECORDS

GEOLOGICAL SURVEY OF

Part 2.] 1873. [May.

THE BISRÁMPÚR COAL-FIELD, *by* V. BALL, M. A., *Geological Survey of India.*

Name.

Position and boundaries.

The above name being that of the capital town has been given to an area of coal-measure rocks which is situated in the eastern portion of the comparatively low-lying ground of Central Sirgújá. On the north and east the limits of the original basin of deposit are defined by, in the former case, a ridge of low hills composed of metamorphic rocks, and in the latter by the flanks of a plateau formed of the same rocks. This plateau rises from 1,000 to 1,800 feet above the generally elevated country of Western Chota Nágpúr; thus forming a step or barrier between Lohardugga and Central Sirgújá.

In some cases the ancient valleys and indentations in these bounding walls of the basin are occupied by prolongations from the rocks of the Tálchír formation, which, as they crop out on all sides, probably underlie the coal measures throughout. Instances occur, notably one, where spurs from the metamorphics penetrate into the area now occupied by the coal measures. With these exceptions the latter lie within well defined boundaries, which, to a comparatively small extent only, have been affected by faults. On the south and west the case is very different. The original boundaries of the coal measures are far removed from the present limits; and broken and semi-detached extensions of the sedimentary rocks, especially the Tálchírs, connect the Bisrámpur field with other coal-fields, which, however, for all practical purposes are, and for purposes of description may be, most conveniently regarded as distinct.

Area.

The coal measures whose limits have been thus defined occupy an area of about 400 square miles, throughout which, except in the river beds or their immediate neighbourhood and on a few small hills, no rocks are exposed: a considerable covering of alluvium concealing all. To such an extent is this the case that a traveller might pass over the Bisrámpúr and Partábpúr road for twenty-two miles without seeing a single outcrop of Barákars, save at two or three of the river crossings.

Drainage.

The level of this area falls gradually from south to north, Bisrámpúr at the south-east corner being 1,943 and Kíunrá on the northern boundary 1,747 feet above the sea level.

The drainage of the eastern three-fourths of the field is effected by [illegible] and its tributaries. The waters of the remainder are carried directly into the [illegible] Pasáng and other smaller tributaries. The Máhán itself joins the Rehr [illegible] few miles to the north-west of the field, in its course traversing a channel deeply cut in the above mentioned barrier of metamorphic rocks which bounds the field on the north. This fact, if others were wanting, affords evidence of the immense denudation which has taken place. But in the isolated Pilká hill, formed of the upper sandstones which rest on the southern boundary of the field, there is a remnant

Denudation.

of the rocks, which, with a covering of trap, filled up the basins and valleys existing in the ancient metamorphic area. Thus, wé can see what were the conditions which gave the river a fall from above, sufficient to enable it in the long lapse of time to cut down through what, under other circumstances, would have been an insurmountable obstacle to the formation of a drainage outlet for this area on the north.

Under somewhat similar conditions, two other considerable rivers, the Kunhur and Rehr, have cut gorges for themselves, through which they are gradually removing away all traces of those rocks whose former presence enabled them to force their way to the Sone.

Thus the valleys and basins are being sculptured and cleared out anew, the sedimentary rocks broken up into detached areas, and the basal metamorphics gradually re-exposed to the direct action of denudation.

Previous observers.

Previous to the first visit of the Geological Survey, the information regarding the existence of coal measures in Sirgújá was of a somewhat hazy character, being chiefly confined to brief notices by the district officers, who in their tours had seen or heard of the existence of coal seams.

Colonel Ouseley, J. A. S. B., XVII, 1848, p. 65.

In a paper on the antiquities of Sirgújá, Colonel Ouseley mentions the occurrence of coal, iron, gold, ochre, marble and lime in that district.

Greenough, Brit. Ass. Report for 1854, and map.

In Mr. Greenough's map the Damúda valley coal measures are connected with those of Sirgújá and the Hutso valley. The incorrectness of this was pointed out in the Report of the Committee on Mr. Greenough's map, appointed by the Asiatic Society in 1866. *Vide* J. A. S. B., XXV, p. 425.

Colonel Haughton, J. A. S. B., 1854, p. 105.

Colonel Haughton states "the Gangpúr coal formation is probably connected with that of Sirgújá and Palamow; but on this point I have no reliable data."

Colonel Dalton, J. A. S. B., XXXIV, pt. II, No 1, 1865.

Colonel Dalton alludes to the occurrence of coal in parts of Sirgújá.

Topographical Survey Maps, 1867-68.

Localities for coal are given on the 1-inch maps constructed under the superintendence of Major Depree and Captain Sale. Reference will be made to these localities in the following pages.

I.—General Geology.

The sedimentary rocks of this area are referable to three formations, *viz.* :—

Tálchír series.

Damúdá series (Barákar group).

Upper sandstones (=Máhádevás?)

Tálchírs.

As to the maximum thickness of the Tálchírs, there are no sections sufficiently definite to enable us to determine its amount with certainty; but in no part of the field where the rocks of this formation are exposed do they reach 200 feet. In the clearest section in the area—in the Goinghatta—the same beds roll over and over and it is impossible to measure them. Outside what we have adopted as the limits of the present description, there may be a much greater thickness, and in one section underneath the Máin pát, they certainly do exceed 200 feet.

Barákars.

Similarly with the Barákars, though occupying a considerable area, there is no tilting or disturbance of the beds for any continuous distance, the consequence being that no measurements can be made which are of the least value for determining the thickness. The prevalence of sandstones to the almost total exclusion of the other rocks which go to make up the Barákar group in the eastern coal-fields renders it impossible to identify individual beds in sections at any distance from one another. And the coal seams are far too irregular and variable in thickness to be of much use for this purpose.

From the general horizontality of the beds, from the character of the basin in which they lie, and the outcropping of the Tálchírs on all sides, it is evident that, as compared with the eastern fields, the thickness must be inconsiderable, and I find it difficult to bring myself to believe that it anywhere amounts to even as much as 500 feet.

Upper sandstones.

With the upper sandstones it is less difficult to assign a definite thickness, though it be a minimum one. The horizontal beds which form the Pilká hill are about 1,000 feet thick.

II.—TÁLCHÍRS.

Extent of Tálchírs.

The natural geological boundaries of the Bisrámpúr coal measures include an area sufficiently limited and compact for convenient description; but such is not the case with respect to the underlying Tálchírs. Were the usual practice—one very well suited to the Tálchírs underlying the coal measures of the eastern basins—of following out the rocks to their extremest limits adopted in Western Chotá Nágpúr, we should find ourselves obliged to follow the extension in one direction towards Riwá and Mirzápúr, and in the opposite some 100 miles or so towards Sambalpúr.

As it has been found with the metamorphic rocks elsewhere, so the Tálchírs, which spread over such an enormous area in Sirgújá, can be most satisfactorily discussed in a general account of the district, apart from their relations to any particular basin occupied by 'coal measures.

In describing the distinct areas of coal measures which occur in Western Chotá Nágpúr, I propose in future to adopt artificial boundaries, which will include a limited margin of the surrounding rocks.

Limits of Tálchírs here described.

In the present instance the Rehr river serves as a very convenient boundary, except for a short distance near Pahárbullá, where the coal measures themselves cross it.

Tálchírs west of Kíunrá.

On the north of the field, outside the fault which bounds the coal measures, there are two patches of Tálchírs. The principal of these situated west of the village of Kíunrá, is of an irregular triangular shape, and is traversed by the Máhán river. The rocks in the lower portion of this area adjoining the fault are pebble and boulder beds, with some hard sandstone: the latter I did not at first recognise as belonging to the Tálchír formation, but further on it is seen to pass into true Tálchírs, which extend up the Súkáiá river for about a mile. A short distance north-east of Sugri these rocks are cut off by a ridge of slaty quartzites. In the upper reaches of the stream just mentioned, outside our limits, there is a strip of Tálchírs the boundaries of which have not yet been mapped.

Tálchírs south of Maháispúr.

The second patch of Tálchírs lies south of the village of Maháispúr; it is of quadrangular shape, and is in area about 1¼ square miles. Its northern boundary is very irregular, a stream which runs with it alternately exposes Tálchírs and metamorphics.

From the position of the faulted boundary, which is well seen in the Bánkí river close by, there can be little doubt that these patches lie outside the run of the fault, but I did not succeed in finding any point where the section showed direct opposition of the edges of the Barákars and Tálchírs.

From the eastern corner of the field, a long irregular strip of Tálchírs runs with the valley of the Máhán towards Uphiá, near which place it probably disappears under the sandstones exposed on the southern face of the Máilán pât. So far as it could be traced between Uphiá and Bárbáspúr, it appears to be unbroken for about fourteen miles. When it does not occupy the present bed of the river, it is often much obscured by alluvium and jungle. The boundaries of this strip are frequently indented by noses of metamorphics and submetamorphics, and there are also several inliers of the same rocks.

Tálchírs in Máhán valley.

The bottom rocks of the Tálchírs in the sections exposed in the Máhán are the boulder bed with very irregular bedding and a hard grit sandstone. Overlying these is a considerable bed of yellowish-green sandstone, which, near Bárbáspúr, has been thrown by a cross-fault against the edges of the Barákars. In the Máhán itself shale beds are of comparatively rare occurrence, but they are exposed in some of the sections in the streams which join it on the south.

One point in reference to the boulder bed, which plasters over quartzites and slates in the river south of the Ránchí and Partábpúr road-crossing, is deserving of especial notice, as it has an important bearing on the origin of that rock. The principal proportion of the boulders are derived not from the underlying rocks, but from the granitic gneisses which occur three miles to the north. One rock, a pink porphyritic granite, which is seen *in situ* north of Tárki, seems to have been a prolific source of these boulders.*

Origin of boulders.

A branch from the strip of Tálchírs above described borders the Barákars southward as far as Karnji. This branch is traversed by the Gehúr river, in which there is a section of sandstones and boulder bed, which continues up to the mouth of the Doldoá stream, where slates and quartzites strike into the river and continue in its bed for several miles.

Tálchírs on eastern boundary.

In the Gágur river west of Karnji there is a very intricate section in which Barákars, Tálchírs, Slates, Tálchírs, Slates, and Barákars are successively exposed.

The jungle on the banks is very dense, and the map is, probably from that reason, deficient in detail, so that it is difficult to trace out the geological boundaries. The accompanying map may, however, be taken as affording a fair approximation to the true state of things. The second appearance of the slates is due to the same cross-fault as that above mentioned at Bárbáspúr. They occur as a very small inlier in the base-beds of the Tálchírs, whose ends are against the Barákar sandstones.

As to the continuation of this fault further south, I could see no satisfactory evidence. Possibly it bounds the Tálchírs south-east of Udúkatrá, but with the streams, in which the Tálchírs are exposed, inclining, according to the map, to the westwards, it is impossible so to represent it.

Fault.

Between Kárnji and Chárgar there is a very small patch of Tálchírs exposed in the low ground.

North-east of Sidmá there appears to be a narrow strip of Tálchírs cropping out from underneath the Barákars, but the evidence of its existence is afforded rather by débris in the stream, than from rocks *in situ*.

Tálchírs north-east of Sidmá.

* In some of the boulder beds which occur in the country west of the Rehr, a considerable proportion of the boulders consist of a reddish quartzite sandstone, probably of Vindyan age, which, if that supposition be correct, must have been transported to their present position from the neighbourhood of the Sone. This could only have been effected through the agency of ice.

Near the village of Bhopoli there is seen the commencement of another bordering strip. which is traceable in the bed and neighbourhood of the Bánki river; thence to Bisrámpúr it is covered and obscured by alluvium; but sufficient is seen to enable two branches of Tálchírs to be traced with approximate accuracy, one extending southwards to the Máin pât, where it is covered by the upper sandstones which underlie the trap, and the other westwards to the Pilká hills, under the sandstones forming which it also disappears.

Tálchírs between Bhopoli and Bisrámpúr.

The first of these branches is between seventeen and eighteen miles long, with an average of about three miles in width. On the east the boundary is throughout natural, but the western boundary is in part faulted, with an inconsiderable throw, against the metamorphics.

Eastern branch.

The best section of the rocks in this strip is exposed in the bed of the Goingháttá, between the villages of Pári and Librá, where sandstones, pebble and boulder beds, and needle shales, all of typical appearance and lithological character, are seen.

Section.

In several of the reaches a peculiar effect is produced by the gneiss boulders, which have been washed out of the boulder bed, and are scattered about on the surface, as though they had been only just dropped from floating ice. One boulder, still *in situ* in the bed, gave the following dimensions 7′ 4″ × 6′ 8″ × 2′=97 cubic feet, and I observed several others which could not be measured, which were still larger. Further south in the valley of the Barnái, where the strip is bounded by two ridges of gneiss hills, the boulder bed, shales and sandstones, all occur, but no clear, consecutive section is exposed.

The Tálchírs which stretch westwards from Bisrámpúr to the Pilká hills, are faulted against the metamorphic rocks along the southern boundary. The line of junction between them and the Barákars on the north, is completely hidden by alluvium, but the probabilities are in favor of its also being faulted, as west of the hill its continuation certainly is so.

Western branch.

The Tálchírs disappearing under the grits and sandstones of the Pilká hill, re-appear on the western side much increased in their lateral dimensions; this is due partly to the original divergence of the boundaries, and partly to the effects of a cross-fault, the position of which is marked by a ridge of fault-rock at the south-west corner of the hills, and by the effects produced by it in the Rámpúr coal-measure area, of which more hereafter.

Between the hills and the Rehr an irregularly shaped area of quartzites cuts the Tálchírs in two parts, running up to both boundaries and being faulted against the Barákars. Resting on these quartzites, are three small patches of Tálchírs, remnants of the rocks which at one time spread all over them. An isolated outcrop of these quartzites is exposed in the Goinghátta section, in which, as well as in the Rehr and its tributaries, Tálchírs are seen in many broken and detached sections.

Quartzites.

The further extension of the southern fault, westwards from the point where it crosses the Rehr, is not at present known. The Tálchírs continue to border the coal measures to within a mile and a half of Pahárbullá, where the latter terminate. At Pahárbullá the extension of the Tálchírs in a southerly direction is limited by a considerable group of quartzite and slate hills, which will probably prove to be bounded on the south by the above-mentioned fault, whose western extension has not been yet traced out.

Pahárbullá.

As stated above, the Tálchírs extend far to the west of the Rehr, underlying one or more distinct areas of coal measures. The present account is limited to that portion of them bordering the coal-field and east of the Rehr.

Tálchírs west of Rehr.

Section in the Rehr.

The boundary between the Barákars and Tálchírs is pretty well seen in the Rehr north of the village of Púndih; but in the surrounding country the rocks are completely obscured by alluvium, and I have been compelled to draw the boundary straight from point to point. It is probably somewhat less regular than is represented.

Proceeding northwards from this junction down the bed of the Rehr, there are greenish and yellow sandstones with some shales and flaggy beds, which are chiefly exposed at the salient points in the bed of the river.

Sandstones what?

East of Sármá there are some rather coarse sandstones, not altogether like Tálchírs, but apparently geologically inseparable from other more typical rocks of that series. A short distance beyond, a nose of submetamorphic-looking quartzites and hornblendics strikes into the river. From the mouth of the Jumarpárá stream northwards for about three miles no Tálchírs are seen in the Rehr, the rocks exposed being for the first mile hornblendics and slaty quartzites, with a west-north-west, east-south-east strike, changing to east and west. Nearly due west of Khopá V. S., coarse granites come in and continue up to and beyond Khopá.

The Tálchír boundary leaving the Rehr close to the mouth of the Jumarpárá stream strikes north-eastwards, passing round the village of Nouápárá.

In the streams north and south of Káronji the rocks are much covered; but where exposed, except at one spot below the village, they are clearly Tálchírs. At that point there are some coarse sandstones, which I could not, as in the previous case, satisfactorily separate.

Gobri sections.

In the Gobri river and its various tributaries which traverse the country between Chungári and Datmá the boundaries between the Tálchírs and Barákars are very obscure. This is owing partly to the imperfections of the sections, partly to the presence of rocks of indefinite character, colored like Tálchírs, but lithologically resembling Barákars.

There is an inlier of Barákars south of Dhorá whose boundaries can only be approximately represented. A reference to the map will explain the position better than any description.

North and north-west from Nouápárá the Tálchír and metamorphic boundary runs with the Gobri, where it is very irregular and intricate. The river exposes granitic gneiss and Tálchír rocks alternately. West-north-west of Kurkáli, a belt of Tálchírs, half a mile wide, occupies the low ground below Káskelá, and is seen in contact with the edges of the gneiss under the east bank of the Rehr.

Boundary at Sálká.

Boulder beds.

Leaving the Gobri the boundary bends round Aginá and Sálká. At the latter place there is a remarkably fine boulder bed. The large masses of gneiss which have been washed out of it, when seen from a short distance, look like rock in situ. A mile north of Kotiá the Tálchírs are cut off by the fault which bounds the field.

Outlying patches.

A few small outlying patches of Tálchírs occur in the metamorphic area which intervenes between the north-west corner of the Bisrámpúr field and the eastern extremity of the Jhilmilli coal-measure area.

III.—Dámúdá Series.

Barákar Group.

Rocks in high ground.

Before proceeding to the description of the rocks exposed in the river sections, it will be well to say a few words on the localities where the rocks appear in the high ground uncovered by alluvium. For the most part the rocks so exposed consist of coarse grits, and pebble beds which form bossy mounds or small hills.

Boundary of Barákars marked by vegetation.

A few very striking instances occur, where the hidden boundary of the Barákars is sharply defined either by the character of the jungle growing above, or by the undulating or sloping character of the surface, as compared with that of the ground, where the underlying rocks are Tálchírs or metamorphics.

Grits at Mukánpúr, &c.

At the north-east corner of the field close to Mukánpúr there are some small mounds of a coarse grit, which are separated from the gneiss by a run of fault-rock. In the country to south-west bending to south as far as Chánchi, there is high ground, some of the hills, as the Bál H. S., rising 100 feet above the plain. The rocks are coarse sandstones and grits, with bands of pebbles, which are sometimes of considerable size and little water-worn.

In the neighbourhood of Koilári there are coarse grits near the surface, most of them excessively ferruginous.

At Bárdhá there are mounds of whitish grit sandstones.

Púnri hills of pebbly grit.

Close to Púndih (or Púnri) there are several small hills, the highest of which is 200 feet above the plain. The principal rock forming them is an open-textured grit with pebbles, which I was at first disposed to regard as belonging to the upper group, as it presented the very strongest resemblance to the rocks of the Pilká hill. However, with the general resemblance which exists between the Barákars and rocks of the upper group, it is, in the absence of any well marked geological features, almost impossible to attempt the separation of such isolated patches. South of the hill there is a run of fault-rock, which marks the continuation of the bounding fault of the north-west corner of the field. So far as I could see. its throw must be inconsiderable. I am the more inclined to regard the Púnri rocks as Barákars, in consequence of the range near Bhatgáon, which is at the same level, being formed of rocks exactly similar to the grits and pebble-beds on the east of the field, north of Chánchi. Towards the south and south-west of the field, as at Sidmá, Bisrámpúr, Karwá, and Jáinnagar the coal-measure rocks are completely concealed by alluvium.

Fault.

In describing the river sections, I shall begin with the Máhán, and then take up the tributaries successively from east to west.

Máhán River Section.—The first Barákars exposed in the Máhán section* are seen near the village of Bárbáspúr, where, as already stated on a previous page, they are faulted against Tálchírs. South of the river Barákars occur outside the fault; possibly some of the sandstones seen in the river too, should be so grouped, but at the fault there is a greenish sandstone which is certainly Tálchír.

Seam.

On the west of the fault there is a small seam of carbonaceous shales with irregular coaly layers.

From this down to the mouth of the Dekiá stream the section exposes sandstones with some carbonaceous shales; but even of the latter, at the point west of Bedrá where *coal* is marked on the published map, there is not a trace of shales, much less any sign of coal. Here as well as at several other points to be noticed in due course, the Topographical Survey must have marked *coal* from seeing drifted pieces lying at those points and not seams in situ.

Seam.

Opposite the mouth of the Dekiá stream there is a seam, of which 4 feet, consisting of coal and carbonaceous shale, is exposed. The coal is of inferior quality, but burnable. The base of the seam is quite concealed by sand and water; possibly there may be a better quality of coal below.

* Disregarding for the present the probable occurrence of Barákars in higher reaches of the river outside the limits of the Bisrámpúr coal-field.

Seam.

Higher in the section there is a considerable seam, which is exposed along the northern bank. The clearest view of it is to be obtained in the next reach.

The actual base is concealed, and the top much weathered and covered by surface débris. Section ascending. Dip variable (rolling).

1.	Shales		...
2.	Coal		5½″
3.	Concretionary shale		8″
4.	Flaky coal	2′	
5.	Concretionary shale		10″
6.	Same as No. 4; portions more coaly; contains much iron, about ...	2′	8″
7.	Concretionary shales	2′	3″
8.	Hard band of strong coal	5′	
9.	Same as No. 6	2′	
10.	Hidden, about	4′	
11.	Concretionary shales		8″
12.	Flaky coaly shale	1′	
13.	Concretionary shale	3′	2″
14.	Similar to No. 8, perhaps a little better	2′	3″
15.	Coaly shale	3′ (15–16)	
16.	Concretionary shale		
17.	Coal, fair	4′	8″
18.	Concretionary shale	1′	6″
19.	Coal		2″
20.	Indistinct concretionary shales alternating with flaky coaly layers ...	12′	

Though this seam, as at present exposed, does not give promise of any considerable supply of first rate coal, it undoubtedly contains much of 3rd or 4th rate quality, which might be easily worked.

Owing to the horizontality of a portion of this seam, and the various rolling dips of other portions, it is impossible to represent its strike and outcrop in one. The line on the map is intended to indicate that the coal is seen throughout the distance marked on the bank of the river, rather than to convey any definite idea of strike.

From this to the mouth of the Patpúriá (Dhariá) stream I did not find any coal-seams, the *coal* marked on the Topographical Survey map south of the site of the deserted village of Pánsidánd having no existence. The principal rocks which are seen are horizontal sandstones, some of the individual beds of which are traceable for several miles.

Seam.

Just beyond the Pátpuriá stream there is a small seam of inferior but burnable coal; the section is—

	Descending.	
Sandstone, about	20′	
Coal	1′	7″
Bluish sandy shales	3′	

After this for about five miles the only rocks seen were sandstones and grits. There is no coal *in situ* at the mouths of either the Ghogor or Bánk, as has been indicated on the Topographical Survey map.

Seam.

At the Koteá and Bhojá road-crossing there is a seam containing about 2′ 11″ of poor coaly shale. It is seen again in the adjoining stream on the east. Where seen in the Máhán it has been let in between sandstones by two small faults. The tops of two other seams are exposed in the two next reaches, at the localities indicated on the map. What the thickness and quality of the coal may be which they contain can only be determined by excavation.

Two seams.

There is no coal at either of the localities marked near the mouth of the Gálphúlá.

In the long south-to-north reach which follows, the lower portion of a seam is exposed, paving the bed of the river for about two miles. A clear section of the top of this seam is exposed near Bhagárá.

Seam.

Seam—Descending.

	Sandstone about	12'	
1.	Blue shale	?	
2.	Coal, portions shaly, but for the most part fair	4'	
3	Blue shale		4½"
4.	Coal, fair, upper 3" stony	1'	1"
5.	Shale	1'	4"
6	Coal like No 4		3"
7.	Shale		8"
8.	Coal like No 4		3"
9.	Blue shale, about		8"
10	Carbonaceous shale		3"
11	Coal like No. 4		?
12.	Shale,—covered.		

Some experiments with No. 4 showed that it does not coke, but retains its shaly shape. On roasting, it evolved gas freely in quantity, see p. 39.

The east-to-west reach beyond this has a deep channel, which retains a considerable body of water. This and a dense grass and tree jungle which clothes the sides render it almost impossible to keep the river in sight.

At the bend to the next reach there is a seam which is possibly only another outcrop of the one just described at Bhagárá. However, it contains less coal, and the constituent layers of coal and shale do not correspond.

Seam.

Section—Descending.

	Felspathic grit sandstone.		
	Interval.		
1.	Blue shale	1'	
2.	Coaly "	1'	3"
3.	Blue "	1'	4"
4.	Coaly "		4"
5.	*Coal*, fair	2'	2"
6.	Blue shale	3'	
7.	Coaly shale	1'	2"
8.	Coarse grey and blue shales	2'	4"
9.	Coaly carbonaceous shale	1'	
10.	Shale.		
	Base covered.		

From this northwards to its junction with the Bánki (Pertabpúr) river, the Máhán exposes sandstones at intervals; east of Durti a fine trap dyke causes a fall in the river. The strike of this dyke in the bed of the river is 15° north of east to 15° south of west. A possible continuation of it is seen in the Johoá, six miles to the west; but in the intervening country and also to the east of the river I could see no trace of it.

Trap.

Beyond the junction with the Bánki, under the eastern bank, there is a small seam which contains some hard coaly shale, but apparently no coal. After this for nearly a mile there are Barákar sandstones; and then no rocks are seen for nearly a mile, the deep channel of the river being filled with water. The first rocks exposed are some Tálchír boulder beds, which crop out from underneath the western bank. The faulted junction is therefore hidden here, but is very plain in sections both on the east and west. North of this the Máhán does not again traverse Barákar rocks.

Seam.

Taking up the tributaries of the Máhán, in regular succession from east to west, the first to be noticed is the Dekiá.

Dekiá River Section.— South-west of Markátánd a nearly horizontal seam of from 1′6″ to 2′ of coaly shale and coal crops out at several places. Above it are ferruginous pebble beds and concretionary iron bands, the former resembling rocks occurring in the upper group, *e. g.*, in the hills near Kussumbi on the Ranchi road.

Seam.

Gagur River Section.—Although Barákars occur east of the cross-fault above described, the river section of these rocks commences at it. They consist of massive sandstones, which are horizontal or only slightly rolling, and are deeply cut by the river. North-west of Udukátrá, a seam of coal is partially exposed on the southern bank underlying these sandstones. Apparently the same seam is again seen at the loop bend east-north-east of Burká-Dhuriá; it there underlies some much honey-combed sandstone. The thickness of coal is about 2′ 4″. At the next reach there is another badly seen seam. Throughout the remainder of the section up to the Máhán the rocks are all coarse sandstones.

Seam.

Seam.

The small streams flowing into the Gágur on the south were not examined in detail, but where crossed, they showed no signs of containing coal. They for the most part are at a higher level than the Gágur channel, and have not yet cut down to the coal exposed in it. The watershed where they take their rise is the spur of quartzite which penetrates the Bará kar area, and which has been already referred to.

Patpúriá River Section.—The Patpúriá stream rises in the high ground of the quartzite spur below Dhuriá, where it passes on to the Barákars. The rocks exposed are of very peculiar appearance; they consist of pebble-beds and coarse conglomerates, which latter contain masses of blue quartz, jasper, and jasper breccia, derived from the sub-metamorphics in the vicinity. Not far off a large fragment of coal was seen, but no seam from whence it could have been derived was discovered. Half a mile from the mouth of this river there is a seam of coal which measures 2′ 11 ; it underlies massive sandstones, and is not improbably a thickened continuation of the seam described in the Máhán section on page 32.

Seam.

The stream east of Khargáoná, which joins the Patpúriá near its mouth, passes underground for some distance east-north-east of the village. At the base of the tunnel a seam of about 1′ 6″ of poor coal, possibly the same as the one in the Máhán and Patpúriá, is exposed. My attention was drawn to this peculiar tunnel by a flock of blue pigeons suddenly rising out of a hole near the road. This hole proved to be an entrance to the cavern, the existence of which I might otherwise not have suspected.

Seam.

Turrá River Section.—The Turrá river, as well as its tributary, takes its rise in the ridge of metamorphic rocks outside the northern boundary of the field, and joins the Máhán rather more than one mile west-south-west of Kertá.

A short distance from the mouth there is a seam under a thick bed of sandstones which contains about 11″ of inferior coal. About half a mile further up the stream, there is a flat seam containing coaly and carbonaceous shales, the thickness of which is uncertain. The map not being plotted, I am unable to say to what exact spot the next locality for *coal* marked on the topographical map may refer. Somewhere in that neighbourhood there are traces of carbonaceous shale, but no coal. Like so many others in Sirgújá, this river proved very difficult to follow up: throughout long reaches the accumulation of the water in the deeply cut sandstone channel rendered it impossible to wade, and the thickness of the jungle on the ravine-intersected banks made it almost equally impossible to keep along the bank in sight of the rocks.

Seam.

The next coal seam exposed is situated slightly south of west of Chourá. It is flat, and paves the bed of the river; portions are coaly, but the thickness is not disclosed.

Seam.

In the western branch of the Turrá called the Gohogor, I saw no traces of coal at the junction. But the river has not been examined.

Bánk River Section.—The Bánk river rises in the metamorphic hills to the east of Bisrámpúr, and joins the Máhán north of Bhojá. It first enters the sedimentary rocks (Tálchírs) near the village of Tákiá. Thence it proceeds northwards along the eastern boundary of the field, bending at one locality into the Barákars, and at another into the metamorphics, and for the remainder of its course up to Ghangri, traversing Tálchírs.

In the Bhiti river, which joins it close by, there is a seam of carbonaceous shale which is seen at the road-crossing below Bakná. In a stream which joins the Bhiti south-east of Bakná, there is another seam containing about 1′ 6″ inches of coaly shale; this is covered by coarse sandstones, the exact position of the boundary between which and the slates is hidden. Returning to the Bánk, the Tálchírs, which occur in the bed of the river north of Ghangri, are gradually covered by pebbly Barákar grits. About a mile from the junction, there is a seam containing about 5″ of good coal; after this, half a mile further, there is a rolling seam which contains 2′ 10″ of shaly coal; it is several times repeated higher up. West-south-west of Abkorá, there is a seam which is exposed by the deep-cut channel included between massive beds of grit. It has a slight inclination to north and a variable thickness, the average being about 2′; it is, like many other of the seams in Sirgújá, in all probability only a lenticular mass with limited lateral extension.

Seam.

Seam

Seam

For about two miles beyond this only sandstones and grits are exposed. But east of Chátásárái there is a seam of shaly coal of which 2′ 1″ is exposed, the base being hidden. The streams which join the Bánk in this neighbourhood from the east did not, at their mouths and for some distance in, give any promise of coal. At the point where the Partábpúr and Bisrámpúr road crosses the Bánk there is a seam, with a slight dip to the south-east, which contains about 8′ of poor flaky coal and carbonaceous shale exposed, the base being hidden. In a stream which joins the Bánk north of Ráimá, there is a seam containing somewhat similar shales. Nearly north-west of the deserted village of Chora, there is another seam with the same constituents; of this 2′ 6″ only is exposed.

Seam.

Seam.

Seam.

For about two and a half miles more the river runs along through a gorge cut in q. p. horizontal beds of massive sandstones and pebbly grits. Nearly due east of Bhojá there is a seam of coal dipping 5° to north, in which there is about 1′ 8″ of coal exposed.

Seam.

The remaining two miles or so of the Bánk, up to its junction with the Máhán, I was prevented from examining by an attack of fever.

Koteá River Section.—In the stream which joins the Máhán south of Koteá, the rocks are much covered, especially near Gourá. East of Koteá, there are sandstones; and close to the mouth there is a section of the seam which is seen in the Máhán, vide p. 32.

Galphúlá River Section.—In the loop-bend of the Galphúlá near Biláro there is a seam containing some coal, about 8″ of which is seen. In an adjoining stream the whole seam, measuring about 7′, is exposed, in which there are seen to be coaly layers mixed up with carbonaceous shales. I do not

Seam.

think there is any promise of good coal being found in workable quantity. This seam has a more decided dip to the north-east than is common, the rocks being for the most part horizontal. Coal was met with south of the deserted village of Jhaprá. The seam consists of carbonaceous shales, with thin layers of coal, one near the base measuring 6″; the dip is 10° to south-east.

Seam.

The same seam is better seen in the Báherádol branch of the river; it is here seen to be of considerable size, and contains about 6½ feet of fair coal. Some of the accompanying shales contain *Glossopteris* and other plant fossils.

Fossils.

There are several other seams containing carbonaceous shale, with portions coaly. One is situated west of Jhaprá and another west of Bhojá; the character of the latter hardly justifies the insertion of *coal* on the Topographical Survey maps.

Seams.

Jhampi River Section.—In the Jhampi from Doin to its junction with the Máhán I only met with one seam of carbonaceous shale associated with the Barákar sandstones. Some fragments of coal, however, indicated the presence of a seam in the area drained by the numerous small tributaries.

Seam.

Chengodri River Section.—From the character of this river and its banks it was absolutely impossible to follow it up closely. The only seam I met with, was one containing 1′ 1″ of coal which is situated at the junction with the Jhámpi.

Seam.

Másán river Section.—As indicated on the Topographical Survey map there is coal in the Másán north-north-east of Járhi; the total thickness of the seam is about 7′, of which 2′ is coal. It dips to north-east. From its more shaly and generally inferior character, I am inclined to think it is distinct from the seam about to be mentioned. This seam runs with the stream for a considerable distance, being last exposed about half a mile from the junction with the Máhán; it contains from 5 to 6 feet of coal, the upper portion of which is very fair. It has an unsteady dip to south-south-west, which never exceeds, and rarely attains 10°. This is the most promising seam in this part of the field.

Seam.

Seam.

Bánki (Partábpúr) River Section.—The boundary of the coal-field crosses the Bánki about two miles north-north-west of Bardhá. The section clearly shows it to be faulted; the edges of the sandstones are presented against the faces of some much tilted and disturbed slates and quartzites, the penetration of which by granite-veins and their relations to the granitic gneissose rocks I shall allude to further on. At the junction on the western bank of the river a thin band of 7″ of coal underlies the topmost sandstone, and is itself underlaid by a greenish yellow sandstone, which I at first thought might be Tálchír, but subsequently concluded to be Barákar.

Seam.

From this to the junction with the Máhán there are more or less horizontal sandstones.

In the Daldali stream, nearly due north of Burdhá, there is a seam of coaly and carbonaceous shale, which with its accompanying sandstones is (locally) upheaved to an angle of 45°; from this to the point where the stream passes into the Tálchírs sandstones only are seen.

Seam.

Nákti River Section.—The Nákti for a portion of its course runs with the faulted boundary of the Barákars, crossing and recrossing it frequently. The only rocks of this group which it exposes are sandstones. In the Márátá branch of the stream there is a small seam of coaly shale of no importance.

Seam.

The Barákar faulted boundary leaving the Nákti north of Narkolá is traceable south of Pakni to Károti, where it is cut off. In several places along it the sandstones are highly indurated.

Rehr River Section.—The Rehr river with its tributaries drains the south-western portion of the coal-field.

The bounding fault of the south-west corner of the Barákars of the Bisrámpúr area crosses the Rehr one mile north-east of Beltikri; the actual junction line is here covered, but Barákars and Tálchírs are exposed at no great distance on either side.

Trap.

In the reach which strikes eastwards from Pachirá there is a trap dyke, which for a mile forms the northern bank of the river; at the other end it is flung by a small cross fault which brings it down to the southern bank. Besides this principal dyke there is a second, irregularly parallel to it, which traverses the sandstones for a short distance.

Seam.

In the next reach there is a coal-seam containing about 18 inches of fair coal. Dip 5° to north-east. Further on there is seam which is, I think, distinct from the last. It is inaccessible, being under a thick bed of sandstone which overhangs a deep pool. It is probably from 15″-18″ thick. Rather less than a mile beyond the junction with the Pasang there is a seam exposed in the bed of the Rehr, of which the measurable thickness is about 3 feet. It has a slight dip, which varies in direction between east and north-east. Most of the coal is fair, and a portion excellent. In the bed of the river beyond this, blocks of coal of considerable size—from what seam derived is uncertain—are abundant and of good quality. They may have been washed out of the seam just mentioned, or carried in from some of the seams in the Pasang. Beyond this seam, up to the boundary, the only rocks seen are coarse Barákar sandstones.

Seam.

Pasang River Section.—East of the Silphili Ghát, the section in the Pasang for about four miles exposes horizontal sandstones only. The same beds persisting throughout.

Seam.

West of the ghát the same sandstones continue for about four miles. In some places the river has cut for itself a deep channel. South of the deserted village of Kasalgiri there is a seam which at first, from the manner of weathering, appears to consist entirely of good coal. On close examination, however, more than half proves to be quite useless, and the remainder inferior earthy coal.

Section—

1.	Carbonaceous shales	8″
2.	Shales with plant fossils	2″
3.	Carbonaceous shale, passing into . ..	1′ 5″
4.	Earthy coal	2′
		4′ 3″

Four seams.

At the mouth of the Chapar river there is a seam, which, so far as it is exposed, consists of slaty carbonaceous shale, with portions coaly. Before the mouth of the next northern tributary there is an inconsiderable seam of coaly shale, which has been locally tilted. Immediately after it the top of another seam is seen under water. Before reaching the mouth of the Ársothá tributary, the top of another seam, containing about 1′ 6″ of coal, is seen at the water's edge, and underlying the massive sandstone through which the channel is cut. This, or a distinct seam, is exposed in the reaches beyond the Ársothá stream; it contains 3′ of coal and coaly shale, possibly more.

Seam.

From this up to the mouth of the Karchá the rocks are covered. But a short distance beyond it a seam is imperfectly seen under the southern bank. Possibly a continuation of the same is exposed at the mouth of a stream which joins the Pasang near the Jáinnuggur and Kúndá road. It there contains 1' 6" of good coal (*vide* p. 39). The top is much weathered, and covered with soil, but the base is well seen. Another seam is badly exposed west of the road, after which up to the junction with the Rehr the only rocks seen are horizontal sandstones. In the Khoá and Gambadiá rivers west of Pilká the Barákar sections contain grits and sandstones only; the latter are sometimes of a somewhat pinkish color, as also are some of those in the Pasang associated with the coal.

Seam.

Gobri River Section, &c.—The character of the sections in the Gobri, with its tributaries the Dámundá, Patpúriá, and Kadáriá, can be best gathered from the map. In so far as the Barákars are concerned, there are no points of sufficient interest to be made the subject of special detail. No traces of coal were met with in any of them.

IV.—Upper Sandstones (Lower Máhádevás?)

Within the limits of the Bisrámpúr coal-measure area, the only locality in which sandstones referable to any of the groups higher than the Barákars occur, is in the Pilká hills, a remarkable looking cluster which stands out isolated in the centre of the Sirgújá plains.

Pilká hills.

These hills are formed of hard quartzose sandstones, grits and pebble conglomerates, the beds of which are horizontal; and the elevation of the top of the highest hill above its base, or about 1,000, may therefore be taken as giving the total thickness.

Thickness.

The evidence here afforded of great unconformity between the rocks of this and the older formations is singularly conclusive. The basal bed of grit laps from Barákars across Tálchírs on to metamorphics, the relations between which had been first established by faults. A doubtful case—not yet fully examined—of similar faulting having taken place in the Barákars previous to the deposition of the upper sandstones, occurs in the hills to the north-east.

Unconformity.

In the Káranpúrá field too, a fault has been mapped as running under the Upper Pánchets.

In describing these rocks, I follow what appears to be now the accepted belief, *viz.*, that the Upper Pánchets of the Damúdá fields are of Lower Máhádevá age, and the general lithological resemblance between the Pilká grits, &c., and the Upper Pánchets, is so strong that I think their identity may be safely asserted.

The only difference that I could detect between the pebbly beds of Pilká and those of Panchet and Lúgú* was that the former are somewhat less ferruginous, in which respect they resemble the Rájmahál grits, which appear to be also referable to Máhádevá age.

On the level top of the hill there is a little soil, but no trace of either laterite or trap. Judging from the similar hills and the plateaus, both to the north and south, trap in all probability at one time did also exist here.

No laterite or trap.

Trap Dykes.

In addition to the general horizontality of the beds, and the small throws of the few faults in the Bisrámpúr coal measure area, the scarcity of trap dykes affords evidence that the rocks have been subjected to a very small amount of disturbance, as compared to that which has affected the more eastern fields.

One trap dyke is exposed in the Máhán section, two miles east of Durti. A possible continuation of it is seen in the Tálchírs and metamorphics, in the Jojhoá stream, seven miles to the west, but no other trace of its continuance beyond the bed of the Máhán was discovered.

Máhán dyke.

* Hills situated respectively in the Ránigaj and Bokáro fields.

The only other trap dyke is seen in the Rehr section, where it runs for about a mile along the northern bank of the river, below Pachirá. At the east end of the reach it has been flung to south by a small fault.

Rehr dyke.

Both the above are coarsely crystalline diorites.

V.—ECONOMIC RESOURCES.

With the exception of building stones which are of the usual character found in the Barákar and Tálchír rocks, the economic resources of the Bisrámpúr coal-field are limited to coal.

Building stones.

From the imperfection of the sections, and the difficulty of identifying the partially exposed coal seams at different localities, any attempt at a tabular statement of the number of seams would only tend to exaggerate the importance of a large proportion of them, which, while they will in all probability prove to be worthless, cannot at present, from the limited data which we possess regarding them, be individually asserted to be so.

Many seams worthless.

It may be regarded as an established fact that good coal does exist in fair abundance, and from the horizontality of the seams, in a suitable condition for working. But borings can alone furnish facts sufficiently reliable for estimating the extent and thickness of individual seams, and generally the total amount of coal existing in the field. Such borings at a few well selected sites, would, in consequence of the undisturbed character of the beds, and the comparatively small thickness of the whole formation, give conclusive and exhaustive information as to the amount of coal obtainable.

Good coal.

Borings.

To prove the individual seams which, as at present exposed, are the most promising, I would recommend borings being made on the west bank of the Máhán, a mile and a half north of Chendiá; on both banks of the Máhán at Bhagárá, and on the southern bank of the Pasang, north of Jaldegá; and from these points in whatever directions the original results would render it probable that the seams extended.

Points for boring.

For proving the total amount of coal throughout the area occupied by the coal measures, borings should be made all across it. It is at present hardly necessary, however, to go further into the question, as the probability of this hill-surrounded area being ever the seat of mining enterprise is so slight that the existence of coal there in whatever quantity can hardly be said to have any immediate importance from an economic point of view.

The coal-fields below the plateau in the Mánd valley, ninety miles to the south, are the only localities in Western Chotá Nágpúr which are ever likely to be made use of by any railway connecting Calcutta and the Central Provinces.

The following is the result of the assays of coals from five localities:—

	COAL SEAMS.	CARBON.	VOLATILE.	
1.	Rehr river near Panri ... ... (water 5·5)	57·7	38·2	
2.	Pasang river, Jáinuggur and Kumdá road	56·2	37	
3.	Máhán „ Bhagárá	50·2	33	16·8
4.	„ „ north of Chendiá	48·5	32·4	19·1
5.	Másán „ ... ... (water 4)	45·5	31·6	22 9

VI.—Metamorphic Rocks.

Two groups.

The metamorphic rocks surrounding the Bisrámpúr coal-field are separable into two groups, chiefly by their respective lithological characters. But their occurrence here, as well as in other parts of Chota Nágpúr, is accompanied by certain geological features, which render it probable that they really belong to two different periods.

Types.

The types of the former group are coarse granitic gneisses with variable amounts of visible foliation. Of the latter the types are slates, quartzites, and hornblendics. Instances occur however where individual beds, lithologically undistinguishable from the latter. are geologically inseparable from beds belonging undoubtedly to the former.

VII.—Granitic Gneiss Series.

The east and west range of hills south of Partábpúr, which bounds the coal-measure rocks on the north, consists of coarse granitic gneisses and schists which are exposed in section in the Máhán, Bánki, and Rehr rivers; in the Bánki section, however, there are also some quartzites, to which allusion will be made again further on.

Trap-like hornblendics.

On the east face of the field, granitic and porphyritic gneisses are again met with near Árá, where they occupy a zone about three miles wide. South of these a peculiar group of trap-like hornblendic rocks form the high ground near Pársá. At first I was strongly inclined to believe these to be trappean, and only relinquished this opinion on finding traces of foliation in some of the sections exposed in the streams on the top of the hill. These rocks continue to the Bánk south of Sonpúr.

Spurs.

The spurs from the high ground east of Bisrámpúr are formed of granitic gneisses with occasional schistose, hornblendic, and quartzose bands.

South-west of Bisrámpúr and south of the Pilká hills, there is an area occupied by metamorphics, which consist chiefly of granitic gneisses. These extend southwards to the Máin pât through Lukánpúr.

Section in Rehr

On the west of the field the section of the metamorphic rocks in the Rehr commences with quartzites of rather uncertain affinities; these are followed by granitic rocks, which continue—occasionally including schistose or slaty beds—up to Jhilmilli.

VIII.—Quartzite and Slate Series.

Section in Bánki.

North of the faulted boundary where it crosses the Bánki, there is a thickness of several hundred feet of quartzites and slates, which present a somewhat very unusual appearance. Granite veins or dykes which are ordinarily confined to the gneissose rocks, in this case pass across into the quartzites, and appear to have been the cause of the disrupted and tilted condition of the beds. In some cases fragments seem to have been torn off from the main mass and are enveloped in the granite. Accompanying this disturbance the slates are much hardened, and the faces are lustrous with crystals of actinolite.

Rocks hardened.

On the eastern side of the field, rather more than half the length of the boundary runs between Tálchírs, quartzites, slates and schists. The extreme irregularity of the surface of the latter at the period of the deposition of the Tálchírs is well shown by the broken character of the boundaries. In the Gehur and Máhán sections many of the slates abound in iron pyrites, which is generally decomposed near the surface and covers the rocks with a copious efflorescence of sulphur. I saw no traces of copper, but from the similarity of the rocks to the copper-bearing beds of Singhbhúm, it is by no means improbable that it may exist.

Iron pyrites.

The Gágar river south of Kárnji traverses a deep gorge, and gives an admirable section of the nearly vertical rocks through which it passes. They consist of slates, indurated shales, quartzites and hornblendics, the last mentioned sometimes exhibiting a cannon ball structure.

One slightly calcareous slate contained a few striated moulds, or impressions of apparently organic objects, but what they could have been has not been determined.

Organic impressions?

A steady strike to nearly west-north-west east-south-east prevails in these rocks. Where not vertical, the dip is to south-south-west at a high angle.

Near the village of Kuthwán, interbedded with quartzites, &c., there is a conglomerate formed of rounded fragments of quartzite, jasper, &c., bound together by a very hard quartzose paste.

Conglomerate.

A spur of quartzites, &c., penetrates for six miles west of the main boundary at Chanchi into the basin. It is not now covered by the sedimentary rocks; indeed south of Dariá it forms some small hills which rise above the general level.

In the stream south of Daria, V. S., the conglomerate just mentioned is again seen; it is on exactly the same strike as the portion of it which is near Kuthwan, or nine miles off.

At Ara, as already mentioned, the granites come in, cutting off the slates. On or about the line of junction, there is a run of limestone, which contains crystals of tremolite.

Limestone.

West of the Pilká hill there are quartzites, which must, I think, be referred to this group; and the hills south of Pahárbullá consist of rocks of the same character.

One notable difference I observe between the rocks of this group as seen in Mánbhúm and Singhbhúm and in Sirgújá, and that is, that the varieties of magnesian schist which are common in the former and furnish a considerable proportion of the total thickness, are nearly altogether absent in the latter.

Absence of magnesian schists.

MINERALOGICAL NOTES ON THE GNEISS OF SOUTH MIRZÁPÚR AND ADJOINING COUNTRY, *by* F. R. MALLET, F. G. S., *Geological Survey of India, (No. II.)*

Limestones.

Having last season found the limestone of the Bíchí nadí* to be a normal dolomite, I collected specimens from various localities this year, in order to ascertain how far this character is general in the limestones of the gneissose series. On analysis I obtained the following results:—

I.—Calcite Limestones.

	A.	B.	C.
Carb. of lime	97·92	83·12	85·92
" " magnesia	1·47	7·04	8·19
" " iron	·38	1·28†	·76
Insoluble	·80	10·16	5·52
	100·57	101·60	100·39

II.—Dolomite Limestones.

	D.	E.	F.
Carb. of lime	67·28	64·68	53·85
" " magnesia	30·24	34·14	45·78
" " iron	·78	·58	·34
Insoluble	·50	·76	1·00‡
	98·80	100·16	100·97

A is a very coarsely crystalline white limestone, from south of Bilwáda on the road from Singraulí to Mirzápúr; B a dark grey fine-grained crystalline rock, from east of Karámi, (sheet 18, Ríwa Survey); C is a white and greenish-white, rather fine-grained crystalline rock, which occurs in subordinate beds through the dolomite E. It weathers with a smoother surface, and is tougher on account of its more compact texture. D is a rather finely crystalline, or saccharine, white dolomite, from the banks of the Rehr, south-west of Ekpai; its composition corresponds nearly to the formula $2CaO, CO_2 + MgO, CO_2$. E is a white rather coarsely crystalline rock from north of Parárwa, having the composition $3CaO, CO_2 + 2MgO, CO_2$; while F is the white crystalline normal dolomite ($CaO, CO_2 + MgO, CO_2$) of the Bíchí nadí already referred to.

It will thus be seen that the limestones vary from pure carbonate of lime to pure dolomite. In some cases, of which C and E are examples, the two rocks are interstratified. The above dolomitic limestones are all associated with more or less serpentine; and I think it may be assumed that where the latter mineral is present in any quantity, the limestone is magnesian. In the only case I have hitherto observed in which serpentine is actually interbanded with the limestone the latter is true dolomite.

Wollastonite.

In the two patches of gneiss east of Koelkat (sheet 18) occurring as inliers in the Tálchírs, limestone is very abundantly met with, the same beds being probably repeated by folding, with a general strike of about west 30° north. It is a white crystalline rock, varying from a saccharine variety to one with cleavage facets of ½ inch across. The band to east of Ráondí contains a very large amount of wollastonite. In fact the rock is entirely composed of this mineral in places, constituting there a 'wollastonite schist,' which from its greater resistance to atmospheric

* Vol. V, P. 19. † With traces of manganese. ‡ Chiefly minute scales of mica.

influences often stands up above the general surface in a low jagged ridge. The mineral has a greyish-white color and bright pearly lustre, and the approximate parallelism of the principal cleavage faces gives the rock a somewhat fissile structure. Tremolite is very abundant in the limestone of the Bíchí nadí;* but the above is the first instance I have met with of the occurrence of wollastonite.

Corundum.

My work brought me again this year to the corundum quarries between Pípra and Kádopání, which I examined closely. The thickness of the bed cannot be determined with any degree of accuracy from the amount of *débris* lying about; but as a rough guess I thought I was more below than above the mark in estimating it at 30 yards at the quarries where it appears to be thickest, and it may be considerably more. The ground is too obscure for one to say with certainty that the above includes no subordinate layers of other rocks, but I observed no indication of such, and for anything I saw for the contrary, the bed may be a solid mass of corundum. It runs about east-north-east, west-south-west, the bedding being vertical or at a high angle. The section previously given† is only true for the spot where it was made, for some of the associated beds die out rapidly. At the west end of the long low hillock which marks the position of the mineral, porphyritic gneiss and white quartz-schist are seen within 10 yards of each other with corundum in the space between. From this to the Rehr, some 300 yards, is obscured by clay, and no trace of the corundum is to be found in the river. East of the quarries again, the bed can only be followed for a short distance, the entire length visible from west to east being, as laid down on the map, about half a mile.

The corundum, where weathered, much resembles fine-grained hornblende-rock in a similar state, and might be easily overlooked. Its intense hardness is well shown by the way in which hammers which may have stood years of ordinary geological work are in a few minutes split and pounded out of shape on it. It seems strange that it should not form a more prominent physical feature. Pluvial mechanical erosion would apparently act very slowly indeed on it, in comparison with the softer rocks on either side, and the absence of secondary minerals in considerable quantity does not point to important chemical alteration. Probably its weak point is the irregular jointing by which it is intersected.

The quarrymen are, I was told, paid at the rate of one rupee per 31½ kacha mánds raised, but the mineral is only worked now and then when a quantity is ordered by the mahájans who deal in it. Before commencing operations a kid is sacrificed to Deví, to insure good fortune, and protection from accident; fires are lighted against the large masses into which the corundum is divided by jointing, and when they have been rendered somewhat more brittle by this means, they are gradually smashed by heaving other pieces at them. Considering the thickness and length of the bed, it is clear that the supply may be considered inexhaustible.

I have described the minerals which are associated with the corundum in my previous note. The only additional species I have observed this year is kyanite, which occurs in a radiating aggregate of a reddish color. It is a mineral, which as a simple silicate of alumina, is a natural associate for corundum, and has been similarly met with elsewhere. There are also small bladed crystals with a bright pearly lustre, much like diaspore, but their small size and the impossibility of detaching them makes their examination difficult. They may be kyanite.

Magnetite.

Beds of magnetite interlaminated with granular silicious layers are met with not unfrequently, more noticeably in the crystalline inliers near Koelkat, also near Gairár and south of Kádopání. None of these, however, are as rich in iron as the magnetic band at Korché in Mirzápúr.‡ Magnetic sand very

* Vol. V, P. 20. † Vol. V, P. 20. ‡ Vol. V, P. 22.

frequently accompanies other arenaceous materials in the beds of watercourses, n some cases probably in sufficient abundance to repay collection by the native iron-smelters. The difference in specific gravity causes a natural separation of the ferruginous and silicious grains, so that the former could be collected with only a moderate percentage of foreign matter, which could be almost wholly eliminated by washing. As far as I am aware however, no attempt is made to utilize this rich detrital ore, while a few miles to the north, the vastly inferior ferruginous beds of the Barákar sandstones are laid under contribution.

ERRATA IN PREVIOUS NOTE, (VOL. V, PAGE 18).

Page 18,	line	8, from bottom,	*for*	Hæmatite	*read*	Tremolite.
20,	"	3,	"	say	"	vary.
"	"	12,	"	chrysolite	"	chrysotile.
"	"	5, from bottom,	"	and	"	to finely.
21,	"	21,	"	or in any	"	or any.
22,	"	4,	"	starry	"	strong.
"	"	5,	"	falls	"	fuses.
"	"	11,	"	white	"	rutile.

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JANUARY 23RD.—COLONEL J. STEVENSON, Deputy Commissioner of Akyab.—An ancient stone implement of Akyab district.

FEBRUARY 26TH.—F. R. MALLET.—A specimen of arsenious acid from Orissa, (artificial).

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MARCH 31ST.—H. WOODWARD, Esq., F. G. S.—Two casts (upper and under surface) of Eophrynus (Curculioides) Prestvicii from coal-measures clay iron stone, Dudley, (Geol. Mag., 1871, Vol. VIII, pl. XI).

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GOVERNMENT OF BENGAL.

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GOVERNMENT OF INDIA.

„ MONTGOMERIE, T. G.—General Report on the Operations of the Great Trigonometrical Survey of India during 1871-72, (1872), flsc., Dehra Doon.

DEPT. AGRIC., REV., AND COMMERCE.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA

Part 2.] 1874. [May.

GEOLOGICAL NOTES ON THE ROUTE TRAVERSED BY THE YARKAND EMBASSY FROM SHAHIDULA TO YARKAND AND KASHGAR, *by* DR. F. STOLICZKA, *Naturalist attached to the Embassy.*

In a former communication I had already occasion to notice, that the rocks composing the Kuenlún range near Shahidula, chiefly consist of syenitic gneiss, often interbedded, and alternating, with various metamorphic and quartzose schists. Similar rocks continue the whole way down the Karakash river for about twenty-four miles. After this the road follows, in a somewhat north-westerly direction, a small stream leading to the Sanju-(or Grimm-) pass. Here the rocks are chiefly true mica schist, in places full of garnets. Near, and on, the pass itself chloritic and quartzose schists prevail, in which veins of pale green jade occur, numerous blocks containing this mineral having been observed near the top of the pass. All the strata are very highly inclined, often vertical, the slopes of the hills, and in fact of the entire range, being on that account rather precipitous, and the crests of the ridges themselves very narrow.

To the north of the Sanju pass we again meet with metamorphic, mostly chloritic schists, until we approach the camping place Tám, where, distinctly bedded, sedimentary rocks cap the hills of both sides of the valley. They are dark, almost black, silky slates, resting unconformably on the schists, and are overlain by a grey, partly quartzitic sandstone, passing into conglomerate. The last rock contains particles of the black slates, and is, therefore, clearly of younger age. Some of the conglomeratic beds have a remarkably recent aspect, but others are almost metamorphic. In none of the groups, the slates or sandstones, or conglomerates, have any fossils been observed; but they appear to belong to some palæozoic formation. They all dip at from 40° to 50° towards north-east, extending for about one and a half miles down the Sanju valley. Here they are suddenly cut off by metamorphic schists, but the exact place of contact on the slopes of the hills is entirely concealed by débris. The schists are only in one or two places interrupted by massive beds of a beautiful porphyritic gneiss, containing splendid crystals of orthoclase and biotite; they continue for about eighteen miles to the camp Kiwáz. On the road, which often passes through very narrow portions of the valley, we often met with old river deposits, consisting of beds of gravel and very fine clay, which is easily carried off by only a moderate breeze, and fills the atmosphere with clouds of dust. These old river deposits reach in many places up to about one hundred and fifty feet above the present level of the river, which has to be waded across at least once in every mile.

At the camp Kiwáz the hills on both sides of the valley are low, composed of a comparatively recent looking conglomerate, which in a few places alternates with beds of reddish, sandy clay, the thickness of the latter varying from two to five feet only. These rock strikingly resemble those of the supra-nummulitic group, so extensively represented in the neighbourhood of Mari. They decompose very readily, covering the slopes of the mountains with loose boulders and sand, under which very little of the original rock can be seen. Near the camp the beds dip at about 40° to north-east, but about one mile and a half further on a low gap runs parallel to the strike, and on the other side of it the beds rise again, dipping with a similar angle to south-west, thus forming a synclinal at the gap. Below the conglomerate there crops out a grey, often semi-crystalline limestone, containing in some of its thick layers large numbers of *Crinoid* stems, a *Spirifer*, very like *S. striatus*, and two species of *Fennestellæ*. Following the river to north by east, this carboniferous limestone again rests on chloritic schist, which, after a mile or two, is overlain by red sandstone, either in horizontal or very slightly inclined strata. Both these last named rocks are very friable, easily crumbling between the fingers, particularly the latter, from which the calcareous cement has almost entirely been dissolved out. At Sanju the red sandstones underlie coarse grey calcareous sandstones and chloritic marls, some beds of which are nearly exclusively composed of *Gryphæa vesicularis*, many specimens of this most characteristic middle cretaceous fossil being of enormous size. The *Gryphæa* beds and the red sandstones are conformable to each other, and although I have nowhere seen them interstratified near their contact, there is strong evidence of their being both of cretaceous age. Both decompose equally easily, and the *Gryphæa* beds have indeed in many places been entirely denuded. They have supplied the greater portion of the gravel and beds of shifting sand, which stretch in a north-easterly direction towards the unknown desert-land.

On the road from Sanju to Yarkand, which first passes almost due west and after some distance to north-west, we crossed extensive tracts of those gravel beds, and of low hills almost entirely composed of clay and sand, though we only skirted the true desert country. Locally, as, for instance, near Oi-tograk and Boria, pale reddish sandstones crop out from under the more recent deposits, but they appear to be younger than the cretaceous red sandstones, underlying the *Gryphæa* beds; the former most probably belong to some upper tertiary group. Among the sandy and clayey deposits I was not a little surprised to find true *Loess*, as typical as it can anywhere be seen in the valleys of the Rhine or of the Danube. I might even speak of 'Berg' and 'Thal-Löss,' but I shall not enter into details on this occasion; for I may have a much better opportunity of studying this remarkable deposit. At present I will only notice that commonly we meet with extensive deposits of *Loess* only in the valleys. Its thickness varies in places from ten to eighty, and more, feet; a fine yellowish *unstratified* clay, occasionally with calcareous concretions and plant fragments. In Europe the origin of this extensive deposits was, and is up to the present date, a disputed question. Naturally, if a geologist is not so fortunate as to travel beyond the 'Rhine' or 'Donau-thal,' and is accustomed to be surrounded with the verdant beauty of these valleys, he might propose half a dozen theories, and as he advances in his experience disprove the probability of one after the other, until his troubled mind is wearied of prosecuting the object further. Here in the desert countries, where clouds of fertile dust replace those of beneficial vapour, where the atmosphere is hardly ever clear and free from sand, nay occasionally saturated with it, the explanation that the *Löss is a subaerial deposit*, is almost involuntarily pressed upon one's mind. I do not think that by this I am advancing a new idea; for,—unless I am very much mistaken,—it was my friend Baron Richthofen who came to a similar conclusion during his recent sojourn in Southern China.

Yarkand lies about five miles from the river, far away from the hills, in the midst of a well cultivated land, intersected by numerous canals of irrigation; a land full of interest for the agriculturist, but where the geological mind soon involuntarily falls into repose. And what shall I say of our road from Yarkand to Kashgar? Little of geological interest, I am afraid.

Leaving Yarkand we passed for the first few miles through cultivated land, which, however, soon gave way to the usual aspect of the desert, or something very little better. A few miles south-west of Kokrabad a low ridge runs from south-east to north-west. If we are allowed to judge from the numerous boulders of red sandstone and *Gryphæa* marl, some of considerable size and scarcely river-worn, we might consider the ridge as being composed of cretaceous rocks. But one hardly feels consoled with the idea, that in wading through the sand he should only cross a once cretaceous basin, and that the whole of this country should have remained free from encroachment of any of the kainozoic seas. It is very dangerous to jump to conclusions regarding the nature of a ground untouched by the geological hammer. The answer to any doubt must for the present remain a desideratum. On the fourth day of our march, approaching Yangihissar, we also crossed a few very low ridges, but these consisted entirely of gravel and marly clay beds, most of them dipping with a very high angle to south by east, the strike being nearly due east and west. South of Yangihissar the ridge bent towards south-west, and there was also a distant low ridge traceable in a north-easterly direction, the whole having the appearance of representing the shore of some large inland watersheet. From Yangihissar to Kashgar we traversed only low land, as usually more or less thickly covered with a saline efflorescence, but still to a considerable extent cultivated. Here in Kashgar the distant heights of the Kuenlún, of the Pamir and Thinshan ranges are ready to unfold their treasures, whether we go in a southerly, or westerly, or northerly direction; geological ground is even nearer to be found in some of the low ridges from twelve to thirty miles distant, while the Moral-bashi forests, lying eastward, invite the zoologist and sportsman. I trust we shall soon be able to see and relate some novelties from our neighbourhood.

Kashgar, 20th December 1873.

NOTE REGARDING THE OCCURRENCE OF JADE IN THE KARAKASH VALLEY, ON THE SOUTHERN BORDERS OF TURKISTAN, *by* DR. FERD. STOLICZKA, *Naturalist attached to the Yarkand Embassy.*

The portion of the Kuenlún range, which extends from Shahidula eastward towards Kotan, appears to consist entirely of gneiss, syenitic gneiss, and metamorphic rocks, these being quartzose, micaceous, or hornblendic schists. On the southern declivity of this range, which runs along the right bank of the Karakash river, are situated the old jade mines, or rather quarries, formerly worked by the Chinese. They are about seven miles distant from the Kirghíz encampment Belakchí, which itself is about twelve miles south-east of Shahidula. I had the pleasure of visiting the mines in company with Dr. Bellew and Captain Biddulph, with a Yarkandee official as our guide.

We found the principal jade locality to be about one and a half miles distant from the river, and at a height of about five hundred feet above the level of the same. Just in this portion of the range a few short spurs abut from the higher hills, all of which are, however, as usually, thickly covered with débris and sand, the result of disintegration of the original rock. The whole has the appearance as if an extensive slip of the mountain-side had occurred. Viewing the mines from a little distance the place seemed to resemble a number of pigeon-holes worked in the side of the mountain, except that they were rather irregularly distributed. On closer inspection we saw a number of pits and holes dug out in the slopes, extending over a height of nearly a couple of hundred feet, and over a length of about a quarter of a mile. Each of these excavations has a heap of fragments of jade and rock at its entrance. Most of them are only from ten to twenty feet high and broad, and their depth rarely exceeds twenty or thirty feet; only a few show some approach to low galleries of moderate length, and one or two are said to have a length of eighty or a hundred feet. Looking on this mining operation as a whole, it is no doubt a very inferior piece of the miner's skill; nor could the workmen have been provided with any superior instruments. I estimated the number of holes at about hundred and twenty; but several had been opened only experimentally, an operation which had often to be resorted to on account of the superficial sand concealing the underlying rock. Several pits also which were probably exhausted at a moderate depth were again filled in; their great number, however, clearly indicates that the people had been working singly, or in small parties.

The rock, of which the low spurs at the base of the range are composed, is partly a thin bedded, rather sandy, syenitic gneiss, partly mica- and hornblendic schist. The felspar gradually disappears entirely in the schistose beds, which on weathered planes often have the appearance of a laminated sandstone. They include the principal jade-yielding rocks, being traversed by veins of a pure white, apparently zeolitic mineral, varying in thickness from a few to about forty feet, and perhaps even more. The strike of the veins is from north-by-west to south-by-east, or sometimes almost due east-and-west; and their dip is either very high towards north, or they run vertically. I have at present no sufficient means to ascertain the true nature of this vein-rock, as it may rather be called, being an aggregate of single crystals. The mineral has the appearance of albite, but the lustre is more silky, or perhaps rather glassy, and it is not in any way altered before the blowpipe, either by itself, or with borax or soda. The texture is somewhat coarsely crystalline, rhombohedric faces being on a fresh fracture clearly traceable. It sometimes contains iron pyrites in very small particles, and a few flakes of biotite are also occasionally observed. This zeolitic rock is again traversed by veins of nephrite, commonly called jade; which, however, also occurs in nests. There appear to be two varieties of it, if the one, of which I shall presently speak, really deserves the name of jade. It is a white tough mineral, having an indistinct cleavage in two different directions, while in the other directions the fracture is finely granular or splintry, as in true nephrite. Portions of this mineral, which is apparently the same as usually called white jade, have sometimes a fibrous structure. This white jade rarely occupies the whole thickness of a vein; it usually only occurs along the sides in immediate contact with the zeolitic vein-rock, with which it sometimes appears to be very closely connected. The middle part of some of the veins and most of the others entirely consists of the common green jade, which is characterized by a thorough absence of cleavage, great toughness, and rather dull vitreous lustre. The hardness is always below 7, generally only equal to that of common felspar, or very little higher, though the polished surface of the stone appears to attain a greater hardness after long exposure to the air. The colour is very variable, from pale to somewhat darker green, approaching that of pure serpentine. The pale green variety is by far the most common, and is in general use for cups, mouth-pieces for pipes, rings and other articles used as charms and ornaments. I saw veins of the pale green jade fully amounting in thickness to ten feet; but it is by no means easy to obtain large pieces of it, the mineral being generally fractured in all directions. Like the crystalline vein-mineral, neither the white nor the green variety of jade is affected by the blowpipe heat, with or without addition of borax or soda. Green jade of a brighter colour and higher translucency is comparatively rare, and, already on that account, no doubt much more valuable. It is usually only found in thin veins of one or a few inches; and even then it is generally full of flaws.

Since the expulsion of the Chinese from Yarkand in 1864, the jade quarries in the Karakash valley have become entirely deserted. They must have yielded a considerable portion of the jade of commerce; though no doubt the workmen made a good selection already on the spot, taking away only the best coloured and largest pieces; for even now a great number of fair fragments, measuring 12 to 15 inches in diameter, form part of the rubbish; thrown away as useless.

The Belakchí locality is, however, not the only one which yielded jade to the Chinese. There is no reason to doubt the existence of jade along the whole of the Kuenlún range, as far as the mica- and hornblendic schists extend. The great obstacle in tracing out the veins, and following them when once discovered, is the large amount of superficial débris and shifting sand, which conceal the original rock *in situ*. However, fragments of jade may be seen among the boulders of almost every stream which comes down from the range. We also observed large fragments of jade near the top of the Sanju pass, which on its southern side at least mostly consists of thin-bedded gneiss and hornblendic schist.

Another rich locality for jade appears to exist somewhere south of Kotan, from whence the largest and best coloured pieces are said to come; most of them are stated to be obtained as boulders in a river bed, though this seems rather doubtful. Very likely the Chinese worked several quarries south of Kotan, similar to those in the Karakash valley, and most of the jade from this last locality was no doubt brought into Kotan, this being the nearest manufacturing town. A great number of the better polished ornaments, such as rings, &c., sold in the bazaar of Yarkand, have the credit of coming from Kotan; possibly they are made there by Chinese workmen, but the art of carving seems to have entirely died away, and indeed it is not to be expected that such strict Mahomedans, as the Yarkandees mostly are, would eagerly cultivate it. If the Turkistan people will not take the opportunity of profiting by the export of jade, or if no new locality of that mineral is discovered within Chinese territory, the celestial people will feel greatly the want of the article, and good carved specimens of jade will become great rarities. The Chinese seem to have been acquainted with the jade of the Kuenlún mountains during the last two thousand years, for Kotan jade is stated to be mentioned* "by Chinese authors in the time of the dynasty under Wuti (B. C. 148—86)."

Yarkand, 14th November 1873.

NOTES FROM THE EASTERN HIMALAYA.

While Dr. Stoliczka is applying his palæontological master-key to discover the secrets of the rocks of the Kuenlún, on the extreme north-west of the great Tibetan mountain-area, investigations of scarcely less interest are going on at the south-eastern base of the same, in the Sikkim and Bhután Doars. It may indeed be said that the geology of the remote and inaccessible regions of the Himalaya have for some time been better known to us than that of the nearer ground to the south of the great snowy range. A series of well-known formations have long since been identified beyond the passes; while the rocks of the broad belt of mountain region to the south of the main range have remained indeterminable. Nummulitic rocks have been locally found along the southern fringe of that belt, corresponding stratigraphically to the Flysch of the Northern Alps. And upon very scanty fossil evidence it has been conjectured that the limestone of the outer ridges in the Simla region are triassic; but for the rest all is darkness. There is, of course, a very good excuse for this in the highly metamorphosed condition of the strata in the greater part of that region, and in the sterility everywhere in fossil remains—difficulties which greatly enhance the value of any promising clue to a solution of the mystery.

From the point of view of local geology this state of ignorance has been specially depressing. That same nummulitic formation—crushed and upheaved on the outer fringe of the Himalayan region, and resting undisturbed upon a deeply denuded surface of the great

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* Yule's Marco Polo, Vol. I, p. 177.

Dakhin trap—has been almost the only positive link between the rock-areas of the Peninsula and of Central Asia. Of the other Indian rock-formations—the Vindhyan series of unknown age, and deeply rooted in the fundamental rocks; or the great sandstone formations supposed at present to range from permian to latest jurassic, and holding a comparatively superficial relation to the supporting rocks—no assignable equivalent had been made out in the neighbouring Himalayan provinces.

The press of work elsewhere may be offered to account for this; for the clue which is now promising such interesting revelations has been within reach at any time for the last twenty years; since Dr. Hooker discovered at the base of the Sikkim Himalaya rocks containing plant-fossils characteristic of the coal-measures of Bengal.*

The illustrious naturalist did not assign any stratigraphical position for the rock in that section; perhaps the only locality where he noticed it, near the Pankábári rest-house, did not admit of such a determination. This is indeed most likely the case; for, the passing observation made in the same spot by so practised a geologist as Mr. W. T. Blanford left the question still in doubt, the suggestions gathered being that the Damudas may occur there only as fault-rock between the schists of the mountains and the tertiary sandstones at their base; or even that the stones containing the Damuda plants may only occur as blocks in the tertiary sandstones. A regular survey of that region is now in progress. Mr. F. R. Mallet took up work there early in December; and already important results have been obtained, both practical and scientific. A band of Damuda coal-measure rocks has been traced for many miles along the base of the mountains, and in places as much as one mile in width, inside the fringing bed of tertiary sandstones. Besides the familiar Damuda plants, several seams of coal occur, in a condition approaching anthracite in composition—having 79·3 of carbon, 7·6 of volatile matter (dry), and 13·1 of ash—but in a flaky granulated (graphitic) state from crushing. The chief point of interest, however, is that there is no marked stratigraphical break between these beds and the slaty and schistose rocks forming the mass of the mountains; on the age of which they will thus give very important evidence. Mr. Mallet has not yet been able to satisfy himself upon the complicated structural questions involved in the section, as to inversion, faulting, &c., but it is hoped that before the close of the season some definite view may be made out. Meanwhile this notice is given of so important a step in the geology of India.

While Mr. Mallet was making these observations on the ground, an independent suggestion to the same effect was received from Mr. H. F. Blanford, whom we consider virtually, as he formerly was officially, a colleague in the study of Indian geology. Mr. Blanford was at Darjeeling on a tour of inspection of the meteorological stations in that part of the province. Ever mindful of his first love, and aware, of course, of Dr. Hooker's original discovery of Damuda fossils at the base of the mountains, it appeared to him that the frequent bands of graphitic matter in the schistose and gneissic rocks of the higher regions might indeed be the greatly transformed equivalents of the carbonaceous deposits of the Peninsula. If this criterion be confirmed by the close study of the stratigraphy, it promises to be of very wide application; for these graphitic bands are as abundant in the Lower Himalaya of the north-west as about Darjeeling. The suggestion too fits in well with the little we know on both sides of the question: Dr. Oldham has always maintained that the coal-measures of India are palæozoic; and the Krol limestone, the uppermost group of the Lower Himalayan rock-series in the north-west, is considered by Dr. Stoliczka to be triassic.

H. B. M.

* Himalayan Journal, Vol. I, page 403.

PETROLEUM IN ASSAM, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

In looking through the literature relating to petroleum, I have not met with any record of the composition of oils occurring in Assam. Burmese-oil, which is perhaps better known under the name of Rangoon-oil, has, on the contrary, been the subject of frequent investigation, and one of the later and most highly interesting papers referring to it is to be found in the Memoirs of the American Academy* for 1867, under the heading of "Examination of Naptha obtained from Rangoon Petroleum," by Warren and Storer.

Having been fortunate enough lately to procure a few notes† showing the result obtained by submitting some Assam petroleum to distillation at varying temperatures, I propose taking this opportunity of placing them on record.

The petroleum experimented upon was obtained from a spring in land granted to Mr. Goodenough, a member of the firm of McKillop, Stewart and Company. The tract, as specified in a letter to the Board of Revenue, embraced "both sides of the Boree Dehing river from Jaipore to the effluence of the No Dehing river to a distance of ten miles on each side of the Boree Dehing, including the lands near the Cherraphong hills, Jaipore, the Makoom river, the Namchik Poong, the Terap river, the Namchik river, the Jugloo river, and the Terok river."

Which spring the petroleum that was tested came from I am unable to say; but it was probably from one struck near Makoom,‡ as the springs in that neighbourhood surpassed any others in the copiousness of their discharge, and evidently attracted most attention.

The first of the systematic borings for oil was commenced at Nahore Poong§ in November 1866; but it does not appear to have been successful, and it was abandoned after having been sunk to a depth of 102 feet. In addition to several other hand-borings, a Mather and Platt steam-boring machine was set working in the latter end of December, and a hole was carried down 195 feet; but with the exception of a few signs of gas, there were no good results.

It appears from the records placed at my disposal that a blue clay was invariably met with, not only in the Nahore Poong borings, but in those at Makoom and elsewhere. It would have been interesting to know whether this clay, independently or in association with some other rock, was a good index to oil; but on this point there is nothing clear.

Whilst the borings at Nahore Poong were proceeding, others were begun at Makoom. Oil was struck in one hole on the 26th March 1867 at 118 feet, and it immediately rose 74 feet in the bore, being 44 feet below the surface. About 300 gallons were drawn, after which it was found not to flow continuously, a circumstance which it was hoped would be remedied by sinking deeper.

As many as eight holes seem to have been put down in the Makoom area, and they were nearly all successful in tapping oil. The yield varied in each.

* Vol. IX, Part 1, New Series, page 208.

† I am indebted for these notes and for much useful information regarding petroleum and coal in Assam to my friend Mr. J. Jenkins.

‡ Lat. 27° 18' North, Long. 95° 40' East.

§ The places recommended during the progress of the borings were—Nahore Poong, Makoom, Borhaut, Namcheck, and Bapoo Poong.

In January 1868, 100 to 125 gallons a day were collected from No. 4, while 550 to 650 gallons were collected from No. 5. The action of No. 5 bore was intermittent. Pure water was spouted for 3 or 4 hours, then almost pure oil for 15 to 30 minutes, after which all action ceased for an hour, or sometimes longer; and then activity set in again. Great difficulty was met with in storing the oil, and it is stated that wooden tanks failed to keep it in. The most copious discharge was from No. 5; and as there was not sufficient storage room, the flow was diminished by fixing a valve to the well-pipe. The pressure was very great, being 30 lbs. to the inch.

The following is a very interesting table showing when the blows of oil commenced, the time the oil continued running, and the quantity of oil given from No. 5 bore at Makoom. The depth at which oil was struck is not given in the returns made by the person in charge of the borings, but the hole was most probably a shallow one like the others.

BORE NO. 5.—MAKOOM.

Table showing when the blows of oil commenced, the time the oil continued running, and quantity of oil given.

Date, 1868.		Commenced to run.	Day and hours running.	Gallons per day of ...	
January	8th	9 A. M.	6 days 15 hours.	530	Stopped gradually.
"	16th	11 "	12 "	1,500	1,500 gallons in 12 hours (very strong blow)
"	17th	11 "	14 "	2,100	2,100 gallons in 14 hours (very strong blow)
"	20th	Midnight	9 "	500	5 0 gallons in 9 hours.
"	21st	10 A. M.	20 "	480	480 " " 20 "
"	23rd	11 "	1 day 13 "	300	300 gallons per day (ran slowly).
"	27th	9-30 "	23½ "	300	" "
"	29th	9-30 "	6 days 15 "	250	Running very slowly.
February	5th	9 "	19 "	500	500 in 19 hours.
"	7th	9 "	2 days	700	
"	13th	2 P. M.	19	1,400	In 19 hours 1,400 gallons.
"	16th	9 A. M.	1 day 6 "	1,600	1,600 in 30 hours.
"	27th	11 "	1 " 5 "	900	In 29 hours.
March	2nd	9-30 "	1 " 6 "	1,700	In 30 hours.
"	7th	9 "	2 days	3,000	3,000 in 48 hours.
"	11th	9 "	1 day 11 "	3,500	In 35 hours, very strong—burst pipes.
"	31st	10 "	31 days 22 "	500 per day.	Valve very little open, to reduce the flow as much as possible.
May	14th	6 P. M.	60 "	450 per day.	
July	14th	11-30 A. M.	3 " 22½ "	400	
"	19th	9 "	4 " 21 "	550	
"	27th	1 P. M.	15 "	600	In 15 hours.
"	28th	10-30 A. M.	3 days 1 "	700	A strong blow.
August	8th	9 "	3 "	500	In three hours, very strong flow.
"	11th	2 P. M.	3 days 10 "	1,500	
"	22nd	9-30 A. M.	8 "	400	In 8 hours.

Here the man who kept the account fell ill, and the one who relieved him never kept any.

The temperature is not recorded.

Mr. Goodenough was not successful in establishing a petroleum-industry. The undertaking failed, as so many others in this country have done, owing to the difficulty of transport. But the prospect of an abundance of mineral-oil in Assam has been proved; and if this splendid province should ever be opened up, fortunes will yet be made in this branch of mining.

Analysis of petroleum.—The sample of petroleum operated upon was black, perfectly liquid, and of rather strong odour. Specific gravity ·971. Water 1·000.

One thousand parts were submitted to distillation, first by the heat of a water-bath, but that being insufficient, it was then heated by direct fire. It began to boil at 460° F.—

llected	1.	20	parts below	500°	F.	
	2.	96·5	between	500°—525°	of sp. gr.	·873
	3.	126·5	,,	525°—550°		·882
	4.	100·0	,,	550°—575°		·892
	5.	133·5	,,	575°—600°		·900
	6.	166·5	above	600°		·918
	7.	133·5				
	8.	166·5			turned solid on cooling.	
		943·0				

There was a small residue of coke.

The first six portions would do for lamp oil, although of rather higher specific gravity than that obtained from American petroleum.

Seven and 8 contain solid paraffin, which can be separated, and the liquid-oil used for lubricating; or, after the first six portions have been distilled off, the whole of the residue in the retort can be used as lubricating-oil.

For the purpose of comparison, I give the result of an experiment upon *Pennsylvanian petroleum.*

Sample.—Greenish black, rather thin oil. Sp. Gr. 882. One thousand parts yielded on distillation—

16·5	parts at	212° F.		
85·5	,,	284°-302°	of sp gr.	·733
95 5	,,	302°-320°	,,	·752
125·0	,,	320°-338°	,,	·766
56·0	,,	338°-356°	,,	·776
52 5	,,	356°-392°	,,	·800
56 0	,,	392°-428°	,,	·848
39·5	,,	428°-518°	,,	·854

all the residue would be for lubricating-oil.

Rangoon-oil.—According to Warren de la Rue's researches yields per thousand parts—

110 parts of oil below			
100 ,,	between		
310	above	600°	which solidifies on cooling.
210		600°	dark oil at the greatest heat.

The paraffin contained in portions 7 and 8 of the Assam petroleum might be manufactured into candles. As compared with a few other substances, the following table shows the number of grains required to give equal quantities of light:—

Paraffin	98 grains.
Spermaceti	120 ,,
Wax (bee's wax)	138 ,,
Stearic acid	144 ,,
Composite candle (made of stearine and stearic acid)	155 ,,

The discovery within the last few years of enormous quantities of petroleum in Canada and the United States, has influenced considerably the manufacture of coal-oils in Great

Britain and other countries. But there are places where coal and bituminous shales may be profitably submitted to distillation, and I believe that our Indian coal-fields offer a fair chance.

The yield of crude oil from a ton of ordinary coal* does not usually exceed a maximum of 75 gallons, and a coal which will yield 50 gallons may be regarded as an excellent article, provided it affords coke enough to supply heat for its own distillation.

RANIGANJ,
1st December 1873.

COAL IN THE GARO HILLS, *by* MR. H. B. MEDLICOTT.

The reported discovery of a new coal-field in the interior of the Garo hills, backed up by the proposal to run a railway through them into Assam, led to a very urgent demand to have the rocks of that region examined. Although nearly encircled by long-settled and fertile districts of the upper deltaic plains of Bengal, that hill-tract has, till within the last three years, remained perfectly secluded in primitive savagery. Partly to remove such an anomaly, and partly to put a stop to the occasional practice of the Garos capturing slaves and taking trophies of human heads among the bordering plains people, it was decided to bring the hill-men under control. This intention was carried out without serious difficulty. The people had of course been long acquainted with the character and power of the white men holding sway over the plains, and submitted to their supremacy almost without resistance. This year I had the pleasure to march through the length and breadth of the land in the company of an English lady, the wife of the Deputy Commissioner of the district, Captain Williamson, the subduer and friend of the Garos, who made his tour of inspection through his dominions to fit in with my geological explorations. In the previous season topographical surveyors had accompanied the several expeditionary parties sent in to take possession; and had succeeded in completing an excellent sketch map of the whole area. One of these officers heard of the coal, and brought it to notice. It would seem that no European actually visited the spot; indeed the description first given of the position could hardly have proceeded from an eye-witness; but samples were procured, and thus the bare fact of coal being there was sufficiently authenticated. The confirmation of the existence of a considerable coal-field in the position thus indicated, warrants brief notice of the situation.

It will probably be remarked that Garo-hill coal is at least familiar by name. In 1841, Mr. Bedford, engaged on the revenue survey of the Goalpara district, brought to notice what he called the Kurribari coal-field, at the extreme west end of the Garo hills, close to Singmari on the old Bramaputra. Some attempt was, I believe, made at the time to work it; and the failure of the experiment does not seem to have been fairly attributed to the failure of the deposits. Again, about two years ago, the civil officers of Mymensing brought to the notice of Government the occurrence of coal on the Sumesary river at the south base of the main range of the Garo hills. The extension of the Eastern Bengal Railway towards Assam was then a pressing question; and I was deputed to report upon the prospects of the coal deposits, particularly those of the Kurribari region, the position of which, close to the great river, gave them special importance. In April 1868 the result of my observations was reported to the Government of Bengal: the existence of a fair seam of useful coal at Siju on the Sumesary was confirmed, the present value of it being questioned, on account of difficulty of access from the plains across some ten miles of low rugged hills. Of all the known outcrops in the Kurribari region, at Mirampara and Champagiri, a most unfavorable account had to

* Cannel coals and bituminous shales yield as much as 120 to 130 gallons of crude oil per ton, but they produce no coke of any value.

be given: the deposit was indeed the same as at Siju, and more favorably circumstanced for working, the measures being quite horizontal, and close to the surface; but the seam contained only a few irregular little strings of coal in a thick bed of clay, resting almost directly upon a platform of gneissic rocks. The only apparent prospect of useful coal there lay in the possible development of the deposit on the same horizon to the deep of the formation in its main basin, on the south of the barrier of crystalline rocks; and I suggested that this point might be determined by a boring in the neighbourhood of Harigaon. The present revival of the question has been as stated above.

THE DARANGGIRI COAL-FIELD. *The coal.*—The sample of the newly found coal, sent for opinion, could at once be recognised as the cretaceous coal of this geological province: the same as that known at Siju, and as that of the tiny field at Maobilarkar on the Shillong plateau from which the supply for the station is obtained. It is a very peculiar coal, having less the appearance of ordinary coal than the younger nummulitic coal of the same region it has a decided brown colour when crushed, and gives a wooden sound when struck: it is moreover impregnated throughout by small nests or minute specks of a resinous amber-like substance. It is thus, of course, a light coal, but a very excellent fuel as shown by its composition—

Fixed carbon	47·7
Volatile	44·6
(Moisture)	(11·5)
Ash	7·7

The position.—Viewed from the south, the main range of the Garo hills is continuous with the face of the Kasia hills to the east, although the aspect is different. Instead of the bare mural precipices of massive sandstone, there is the steep rugged slope formed on contorted crystalline rocks, and thickly wooded throughout. The chief orographical difference, however, is that whereas from the scarp of the Kasia range the ground still rises for some distance, passing into the elevated plateau of Shillong, the western range is only a narrow-crested ridge, descending rapidly, though much less precipitously than on the south, to a broad region of steeply undulating hills of much less elevation. The Sumesary river, the Semsang of the Garos, passes through the main range by a deep gorge just above Siju. At the head of this gorge there is a fine waterfall, close to Jankaray; and half a mile further on, just above the confluence of the Rengchi, the river crosses the south boundary of the Daranggiri coal-field, which thus at present lies in a true rock-basin, passing below the main drainage level. The elevation here may not be more than 300 to 400 feet above Siju. The Sumesary flows for six miles through the coal-basin, the north boundary being about one mile below the village of Dobakhol. For the greater part of this length, the river is here the boundary, as recently laid down, between the Garo and Kasia hill districts. The range of the field to the east has not been determined. To the west it extends at least four miles from the lower reach of the Semsang, up to and beyond Daranggiri.

Outcrops.—Several fine outcrops are freely exposed; the one originally reported being by no means the most conspicuous. It occurs in the Garigithem stream, a furlong or so above the confluence with the Semsang. It is 6 to 8 feet thick, with a steady southerly dip of about 4°, the floor of gneissic rock appearing at a short distance higher up the stream. In the main river, about half a mile above the same confluence, the seam appears again in equal force, with a low easterly dip. The correct inference, that the seam would be found continuous through the intervening spur, led to the original announcement of the discovery as of "a mountain of coal." It was close to Daranggiri village that I observed the finest outcrop; it is well exposed for many score yards at the base of the cliff along the right bank of the stream, almost horizontal, and with a thickness of full 7 feet throughout, being at the same time very free from shaly partings. Near the south boundary of the field, along the base of the permanent rise of the main range, the coal was found in two places; but here it has the disadvantage of having undergone much disturbance. In the stream a little to the west of the lower village of Baduri, a few yards below the Daranggiri path, the coal is thus seen in full force, but nearly vertical. On the same strike, within a mile of the Semsang, on the path between Baduri and Jankaray, the approximate position of the seam is marked by large and abundant débris.

On the evidence of these facts, it is, I think, safe to conclude that there is here a coal-field of considerable extent. The coal-measures are certainly continuous within the area demarcated by the localities I have mentioned, covering roughly about twelve to fifteen square miles; and although the coal itself is probably not co-extensive with the measures, the total quantity must be very large; and it is favorably circumstanced for mining. It lies, however, in the very heart of the Garo hills; but on the most favorable line for a railway, through the gorge of the Semsang, should it ever be thought advisable to undertake such a work. The nummulitic formation with its limestone caps the high ground in the centre of the basin.

The Rongrenggiri basin.—Some miles up the valley of the Semsang, to the west, there is another considerable basin of the coal-measure rocks, occupying the valley above and below the Rongrenggiri outpost for a direct distance of seven miles, from a little below Sarramphang Haut to below Shemshanggiri. Locally it is five miles wide. I could nowhere find an outcrop of the coal within this area; but there are stratigraphical features (see further on) suggesting that it may exist within the basin at greater depths than the present surface.

The Kalu basin.—On the Upper Kalu, north of the main gneissic range, about Chipagiri, there is a small basin of the coal-measure rocks; but no trace of coal has been observed. Here, too, it may possibly be found at greater depths by boring; but the field would seem to be shallow and closely circumscribed by the gneiss. Even if found, there would be several miles of difficult transit to get the coal to market.

The main basin.—Every other observed appearance of the coal-measure rocks to the north of the Tura range (excepting one narrow strip in the valley at Lenkra, in the far east), consists only of patches of variable extent and thickness, resting on the ridges and spurs of the crystalline rock, some occurring locally near the Semsang even on the crest of the main range. In so steeply eroded a country, these cappings of sedimentary rocks are freely exposed on all sides to denuding action, and the presence in quantity of any peculiar material could scarcely escape detection; where, too, at any time a shallow trench down the hill side across the bedding would lay bare the whole contents of the section. Yet in none of the very many places where I crossed the measures in this position did any symptoms of coal appear. With the single exception of a small patch on the north shoulder of the ridge below the village of Ṣokadam, every observed outlier of the cretaceous formation occurs within the basins of the Semsang and the Kalu, in the neighbourhood of the main axis of elevation; the whole stretch of hills for twenty miles on the Goalpara side being, at least on the two tracks crossed by me, entirely formed of gneiss. The original sites at the extreme west end of the hills, at Champagiri and Mirampara, remain as the only known cases of the seam being represented in a mere remnant of the measures on a low platform of gneiss. Thus, excepting in the very doubtful project of a railway through the Semsang gorge and the Daranggiri basin, and also in the unlikely possibility of still finding a detached basin within easy reach of the Goalpara boundary, the only prospect of a coal-supply still lies in the main basin of the formation, to the south of the Tura range.

The chances of this prospect are briefly as follows: It is demonstrable in the Khasia hills and here, that the portions of the cretaceous rocks found on the gneiss or within its southern limit are only the marginal deposits of a formation expanding greatly in thickness to the south. Even within that marginal area, coal seems to have been formed only in local depressions of the old land-surface. The important question then occurs—how was it in the main depression of deposition? For the Khasia portion it can positively be said that the conditions for the accumulation of vegetable remains did not exist to the deep of the formation. The whole expanded series is fully exposed in a nearly vertical position at the base of the range; and marine fossils occur throughout. Even the horizon of the coal near the base of the series can sometimes be determined here by the presence of plant-markings and fragments of the resinous substance so common in this cretaceous coal, but here mixed with marine shells. The change to the westwards has not been traced out continuously along the strike; but at the Sumesari it is already very marked: there is a strong seam of coal, well up from the bottom beds; it is brought up twice by contortion of the strata, showing its extension to some distance from the rise; and no marine fossils have been detected in the associated beds. This, it will be recollected, is close on the same meridian as the Daranggiri field, only to the south of the main range. To the west of the Sumesari a very great change takes place in the mechanical circumstances of the strata: instead of being thrown on end at their junction with the gneiss, as is the case everywhere to the east, the boundary here is, what is called, overlapping—the strata being banked against the flanks of the mountain, each succeeding layer overlaps and conceals the one below it. There has been here too some elevation, compression, and waving of the strata; but, on the whole, the formation is only exposed to the depth to which the local streams have cut through the superposed strata. All this is admirably exposed in the ravines below Tura; each layer being for the short space of its overlap the local bottom layer of the formation. In some of them sticks and strings of coal occur, as under Machakholgiri; but it seems likely that none of these streams touch the true horizon of the coal deposit; so that this may be in full force to the deep of the basin. In none of the beds of this region have any marine fossils been detected; and there is very abundantly here a white fine clay-rock,* that hardly appears in the Khasia sections. On the whole, I think the question of coal or no coal in this position ought to be set at rest by a trial boring. I have recommended Dipkai, about two miles to north-east of Putimari Haut, as a suitable spot.

GEOLOGY.—I would add a few remarks of a more general nature to bring my recent observations into connexion with what I have previously said on the geology of this region (see Mem. Geol. Sur., India, Vol. vii, p. 151). The difference of the structural features of the sections in the Khasia and the Garo divisions of this continued mountain-mass is greater than was then surmised. In the Shillong region, the elevation of the plateau took the form of an equable rise of the whole area—the gentle slope of the cretaceous strata from the edge of the scarp, passing into perfect horizontality as they extend northwards, is perfectly unbroken. In the features then observed along the outer base of the range, there was nothing to suggest its being otherwise in the Garo region; a gradual diminution of the elevatory and contorting action being the only change apparent. It would seem, however, that, besides a general decrease in vertical effect, the elevating action here was almost confined to the axis of the range, corresponding with the line of the scarp to the

* This rock may yet be found valuable as a pottery-clay. It contains 52·8 per cent. decomposable by sulphuric acid, and free from alkali iron and lime, with a residue of 47·2 per cent. of pure fine silica.

east; and even, that special local depressions took place to the north of that axis: not only are the same geological horizons found at about the same level on both sides of the ridge, upon which intermediately remnants of these very beds are found at much higher levels, but also, as is very clear in the case of the Rongreng basin, steady local sinking took place, the nummulitic limestone being found in the middle of that small area at the river's level, while the cretaceous sandstone passes up to a considerable height on the spurs of the adjoining hills, no high dips being introduced.

It is interesting to trace the apparent connection of these effects of disturbance with pre-existing conditions. The manner in which the coal occurs in the Darang basin strongly suggests that its limits are to some extent aboriginal, and therefore that the Semsang valley itself was lined out in precretaceous times. At the Garigithem outcrop and also in the Semsang there are about fifty feet of sandstone between the seam and the gneiss. But as it rises along the spurs to the north and west, one finds a far greater thickness of sandstone without any sign of the coal, which is thus simply overlapped; the beds on the high ground, even in contact with the gneiss, being of a higher horizon than the coal. Half a mile above the main outcrop in the Semsang there is on the right bank a cliff of sandstone resting on gneiss, and at forty feet from the base there is a highly carbonaceous shale representing the coal seam.

The manner in which the sandstones are banked up against the Tura range, and fill up inequalities in its surface, is quite conclusive on the same point. The spur on which the station of Tura stands has a midrib of gneiss, packed in sandstone, through which the old ravines have been re-excavated. On the section through Siju and Baduri this would not appear, the crushing having assumed a peculiar and intense form; the separating rib of gneiss, here representing the Tura range, is only four miles wide, and at the base on both sides the coal measures lie at nearly vertical angles against the gneiss and parallel to its surface, while high on the intervening ridge patches of the same rest flatly. Thus it would seem that elevation by lateral compression takes effect by increasing existing inequalities; as would indeed result from the crushing of a series of inverted arches.

ON THE DISCOVERY OF A NEW LOCALITY FOR COPPER IN THE NARBADA VALLEY, *by* V. BALL, ESQ., M. A.

The Bijour or submetamorphic rocks of India have, as has been predicted from their character, proved the principal source of the useful and precious metals which have hitherto been found in this country. The slates, quartzites, and schists which compose the Bijour formation resemble in their lithological characters those metamorphic rocks which in all countries are the most productive of metalliferous deposits.

The discovery of a deposit of copper now to be recorded was made towards the end of last year, on a small island in the Narbada river close to the Birman ghât. The gentleman to whom the sole credit of this discovery belongs is Mr. Charles Maynard, agent of the Narbada Coal and Iron Company. Being well acquainted with the appearance of the ores of copper, some stains of the blue and green carbonates upon the rocks attracted his attention. He at once determined to open up the ground with the view of ascertaining, so far as possible, the extent and character of the deposit.

On the 11th of January, I visited the scene of operations and found that a 'drift' had by that time been driven down to a depth of nine or ten feet. This gave me an opportunity of examining the character of the deposit. The rock in which the ore occurs is an argillaceous schist associated with quartzites. In some of the beds of the latter the component grains are very distinct. These rocks belong to the Bijour series.

I found that the underlie of the deposit corresponds to the dip of the strata, amounting to from 50° to 55° north, the strike being at this particular point east and west. The ore, I believe—as I found also to be the case in Singbhum*— does not occur in what can be truly called a lode, but as a constituent of the schist which it permeates throughout a thickness of at least six feet. This was the thickness exposed at the time of my visit; but according to Mr. Maynard's calculation this should be increased by eight feet; thus making in all fourteen feet as the thickness of the schist permeated by the ore.

There is, as usual, in such deposits, a tendency to the formation of nests and pseudo-lodes; but this, I believe, to be due to subsequent action—seggregation—and that the copper should be regarded as a constituent of the schist as originally deposited.

The ores on the back of the lode, as is generally the case, consist principally of the blue and green carbonates (*Azurite* and *Malachite*). As the mining progresses, nests of the grey oxide become more abundant, and there are also some traces of the red oxide. Pyrites (the yellow metal of mining phraseology) has not yet been reached, nor can it be until a depth sufficient to have ensured its protection from the decomposing effects of atmospheric action has been arrived at.

The extension of the ore downwards or "to the deep" can only be determined by mining. As to its lateral extension we found some stains of the carbonates on the same bed of schist fully 100 yards to the east of the present drift.

Trenches cut across the strike of the rocks to a depth of three or four feet would probably be sufficient to prove the lateral extension sufficiently for all present purposes.

As to the quality of the ores, the assay of five specimens by Mr. Tween yielded the following percentages of copper: No. 1, 47·8; No. 2, 21·2; No. 3, 32·0; No. 4, 25·4; No. 6, 12·6.

Two specimens sent to the mint gave the following result:—

	A	B
Copper	32·75	23·1
Iron	2·50	5·4
Earthy matter	64·75	71·5
	100·	100·

These results must be considered eminently favorable. The quantity in which the ore occurs, the cost of its extraction and transmission to market,† are the elements which now remain to be ascertained in order to determine the full importance and value of the discovery.

The last accounts which I received from Mr. Maynard represent the mine as progressing favorably. Under his energetic management there is a prospect thus of a new industry being started in the Narbada valley.

* See Records of the Geological Survey of India, Vol. III, pt. 4, p. 94.

† It does not of course come within the scope of this notice to discuss the question as to whether it would pay best to export the ore in the form of 'regulus,' or attempt the manufacture of copper on the spot.

POTASH-SALT FROM EAST INDIA.*

A novelty which has become known here through this year's Universal Exhibition is the discovery of Potash-salt bearing strata in the Mayo mines in the Salt-range in the north of the Punjab.

Dr. T. Oldham, who provided and arranged the very interesting exhibition of East Indian mineral products, has already made a communication upon the position of the rock-salt in those hills in a notice published in the *Ver. der Geol. Reichsanstalt,* from which it appears that this rock-salt group is considered to belong to the Silurian formation, and accordingly is the oldest among the known deposits of salt.

Recently attention was drawn at the above-named salt-works to the occurrence of a salt which, by its exceptional hardness, and the more searching examination of the resident chemist, Herr Warth, revealed the presence of a considerable proportion of Magnesium and Potassium.

Specimens from this deposit now in the Exhibition, consist of a white or reddish granular mixture of Sylvine (Chloride of Potassium) and Kieserite (Sulphate of Magnesium).

The Sylvine and the rock-salt can be at once recognised by the cleavage and blow-pipe reaction. The Kieserite appears in grains which have a maximum diameter of 12 mm. It is colorless, and possesses the same hardness and cleavage as that given by me for the Hallstadt mineral.† In places the Kieserite appears also to be compact.

The contained water amounts to 12·99 p. c. exactly, thus agreeing with the calculated amount 13·04.

From the Kieserite in a moist atmosphere changing into Epsomite, the samples in which that ingredient predominates become quite disintegrated at the surface, and exhibit a constantly deciduous coating. Many pieces consist almost exclusively of Sylvine. Whether also some Kieserite occurs in these samples, as may be conjectured in such an association, does not yet appear, since I have only been able to submit small pieces to examination.

The discovery of this Sylvine-bearing salt-band cannot fail to arouse attention in England, since, in spite of the difficulties of transport, a profitable exploitation is possible.

T.

NOTES ON THE GEOLOGY OF THE NEIGHBOURHOOD OF MARI HILL STATION IN THE PUNJAB, *by* A. B. WYNNE, F.G.S., &c.

The outer Himalayan hills on the borders of the Northern Punjab present a marked alteration in the general direction of the Indian frontage of these mountains. The prevalent north-westerly strike of the Western Himalaya is here lost, and this most northerly corner of the Indian Empire is embayed between the approaching masses of the Himalaya, Hindoo Koosh, and Suliman ranges, the outworks of which have various westerly and northerly directions. On the Himalayan side, as noticed by Mr. Medlicott (Mem. Geol. Sur., Vol. III, pt. 2, p. 90), in the valley of the Jhilam river, the hills to the eastward possess the normal north-westerly strike, while on the opposite side of the valley they run in directions nearly at right angles to the former. On one of the most lofty of the minor ridges closing in this Jhilam valley to the west is situated the hill station of Mari, at an elevation of more than 7,000 feet above the sea.

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* Translated from the Jahrbuch der K. K. Geologischen Reichsanstalt, XXIII, No. 2, p. 136.—V. B.

† Sitzungsber., J. Wiener, Akad. Bd. LXIII, p. 305.

Besides the features noticed, the mountains on either side of the Upper Punjab embayment are more or less united by two lower ranges of hills, of which the most southern is the Salt Range, dividing the broken undulating Potwár or Ráwal Pindi plateau from the lower deserts and 'Doabs' through which the five great rivers of the Panjab pass towards Sind. The other less defined group of hills stretches from the Hazára mountains, by the Chita Pahár ridge to the Affrídi hills, towards Kohát, separating the Ráwal Pindi plateau from the Peshawar plain. Within this cluster of hills are large open spaces of low ground cut up by ravines similarly to the Potwar plateau,* partaking somewhat of the direction of the two last named ranges and closely flanking the Hazara portion of the most northern group of the two. The Mari ridge rises among numerous other hills near the village of Chattar Síla, then passing in a north-easterly direction by Trót to Mari culminates there at Pinacle hill (7,467 feet) overlooking a spur called Kúldanna, which unites the main ridge with the more massive Murchpuri mountains to the north.

From Pinacle hill the Mari ridge bends to the east by south for a couple of miles, separating the head waters of the Sohan, a tributary of the Indus, from those of the stream which occupies the *khud* between Murchpuri mountain and Dewal, falling into the Jhilam near Kohala. At Topa summit the ridge regains its north-easterly direction, and passing by Dewal inclines still more to the north, descending gradually till it reaches the banks of the Jhilam river.

Southward from this Mari ridge the hills on the same side of the Jhilam valley consist of four or five other ridges, all having the same general direction, starting from the Potwar plateau with a general strike of E. 30° N., but bending northwards as they rise, and where they decline into the valley of the Jhilam having a bearing still more to the north than north-east. Most of these elevations are sharp-crested, the hill country presenting a succession of deep steeply sided khuds or valleys, but southwards the lofty plateaux of Narh and Karor are striking exceptions to the rule.†

Northwards from Mari the same north-east and south-westerly run characterizes the hills; but for some distance both north and south of the station the ridges seem to branch east and westerly from a crooked back-bone or mid-rib rudely parallel to the course of the river Jhilam. This is less prominent to the south, but coincides with the most lofty summits to the northward, carrying the watershed between the Indus and Jhilam away to the northern side of the Kaghán valley.

Another feature of the hills immediately near Mari may be noticed, namely, the occurrence of small nearly horizontal patches of ground at high elevations formed of unstratified light-coloured clay. Advantage has been taken to level the surfaces of two of

* These open spaces and the adjacent hills afforded the site of the military operations connected with the Northern Camp of Exercise in 1873 near Hassan Abdal.

† It is said that when the sanitarium was being formed at Mari there had been some intention of adopting the Narh plateau as its site instead. The reason given against this is want of water at the latter site; but the natives have another legendary one connected with the displeasure of the local Pir or spirit, who is said to have caused such inconvenience to the inhabitants of the first hut built at Narh that the '*Saheb log*' departed and left the Pir in peace

The elevation of the Narh plateau is only about 1,000 feet lower than Mari; the form and size of the plateau, which is cultivated in places, would seem to offer a much more capacious and better building ground while the size of the catchment area and disposition of the strata are vastly more calculated for retaining a supply of water. The distance from Rawul Pindee station is rather less than that of Mari. The road-making difficulties are less, so far as the hardness of the rocks is concerned, but this renders them less suitable as building stone; snow lies here much shorter time. The plateau is not covered by forest; timber, however, abounds on the northern slopes of the neighbouring valleys. There is a well-made country road now for more than half the distance from Ráwal Pindi, and as permanent quarters for troops, the site appears to possess, on the whole, natural advantages superior to those of the hill of Kuldauna, at the same elevation, where extensive barracks are in course of construction at present.

these, so as to form the cricket-ground at "the Flats," three miles below the station on the Kashmir road, and for the croquet or archery ground south-west of Pinacle hill. Both of these localities are situated on the very back of the ridge; near the former rises the summit of Topa; but the latter, at a much greater elevation, is commanded by no greatly higher ground in its immediate neighbourhood. The clay in both cases is evidently water-washed detritus, and it is not easy now to suggest where the ground was once situated which formed the catchment area to cause these deposits, though they indicate clearly enough a former different configuration of the hills, and point to adjacent masses above them having been entirely removed by meteoric denudation. Such facts as these, and the constant occurrence of landslips on the slopes of these steep ridges, all more or less 'dressed' to a uniform inclination, force upon the observer a recognition of the slow but enormous atmospheric erosion by which these khuds and ridges have been formed, here doubtless largely aided by the periodic rains and winter snows.*

The rocks of which the Mari ridge itself is formed, and all those for a long distance southwards, present a sameness amounting to monotony. They belong to a vast series of alternating gray or purplish sandstones and deep purplish-red clays, with occasional finely concretionary pseudo-conglomeratic bands. The series forms one of the lowest sub-divisions of the great outer tertiary zone of sandstones, clays, and conglomerates, coincident and co-extensive with the southern frontage of the Himalayan mountains. It is evidently the same group of rocks as one of the lower divisions of Mr. Medlicott's sub-Himalayan series, in the Simla country, apparently corresponding to the Dagshai beds of that section; but this being still debateable, it has here been called provisionally after the station—'The Mari Group.' Its thickness is difficult to estimate owing to the contorted positions of the beds, but it must be very great; indeed, from an observation where the same rocks were locally less disturbed in Kashmir, the group may considerably exceed 5,000 feet.

To the south the Mari rocks are succeeded by very similar red clays and grayer or bluish sandstones passing upwards into soft light gray sandstones, having local strings of lignite, and alternating with rusty orange clays. The latter are succeeded by conglomerates as described in a previous paper in these Records (Vol. VI, part 3).

The strata composing that half of the Mari ridge descending towards the Ráwal Pindi plateau are either contorted or present a steep inclination towards the north-west, as though to pass beneath the limestone hills forming the opposite side of the khud in that direction. This feature is nowhere more marked than towards the south-west end of the Mari station, where it may be seen in sandstones and clays all round and over the observatory hill, the outcropping edges of other strong sandstones underlying these beds being traceable along the adjacent side of the khud to the south-east; and the same strongly marked dip being plainly visible from side to side of the ridge in the height overlooking the Lawrence Asylum and the Mari brewery. It occurs again on the road to Kashmir and in other parts of the station; but is not universal, for towards Kashmir point there are many inclinations to the westward and southward of west, chiefly on the northern side of the ridge, while over the continuation of this, towards Dewal and Kashmir, the latter and other dips in different directions indicate the contorted state of the beds. It is perhaps owing to this circumstance

* The well known Himalayan feature of the forests being confined to one aspect of hills, particularly those in which the *Paluder* tree, (*Pindrao*, or *Pinus Smithiana?*) predominates is well marked about Mari. Here the densely wooded slopes are those presented most to the northwards or north by west, the opposite or sunny side being often nearly bare of trees. The forest at Mari ends sharply at the summit of the ridge, and yet Paluder forest may be seen creeping down the south-western slopes of Chumba peak above Khairagali on the upper road to Abbottabad as if the exception were necessary to prove the rule.

and to the less steep form of the ground that this north-easterly half of the Mari ridge possesses its strongly marked red colour, the red clays having a larger surface exposure and being less liable to rapid removal by the action of rain.

The prevailing dip of the Mari rocks, towards the higher hills adjoining, is a strikingly abnormal feature in the structure of the country, and not to be relied upon in estimating the relations as to succession among the rocks of these hills. Notwithstanding this, it is a feature remarkably prevalent along hundreds of miles of the junction between the outer tertiary belt and the nearest of the other rocks of the Himalaya ranges.—It is also to be found along the foot of the Alps in a similar relative situation. (See Mr. Medlicott's report previously quoted, and his "Alps and Himalaya, a comparison,"—Jour. Geol. Soc., Lond., February 1868).

If this north-westerly dip were to be looked upon as indicating the succession, and unconnected with faulting or other complexity (see Geol. Sur. Records, Vol. VI, pt. 3, and Jour. Geol. Soc., Lond., December 1873), then it would follow that the rocks north-westward of the ridge must be newer than those of the Mari series, which is not the case.

Taking this north-westerly dip to be the prominent stratigraphic feature of the Mari ridge, associated, however, with other flexures of the beds, these will be found to bend over an anticlinal axis coinciding with the khud immediately south-east of the station, the first of a series of undulations, which becoming more open pass through all the hills to the southward on this side of the Jhilam valley.

The synclinal axes of these undulations seem to rise towards the eastward, steady low dips in the opposite direction being visible from Mari in the precipitous flanks of some of the distant hills on this side of the Jhilam, as in that supporting the plateau of Narh and others.

About Mari itself the rocks possess but little interest in detail; they contain only, so far as is known, obscure vegetable impressions; and there is not even evidence to prove whether they are of marine or freshwater origin. Close to the station, however, in the khud between it and the limestone hills opposite, about Clifden, on the connecting ridge of Kúldana and along the upper road to Abbottabad, the local geology becomes much more attractive and important, although obscure and difficult to work out owing to the crushed and fractured state of the rocks.

The lofty masses which fill the front of the mountain-landscape northwards from Mari, strike the eye at once as being of different rocks from those of the Mari ridge; their naked or, for the most part, unwooded slopes permitting the gray limestone of which they are so largely composed to appear and influence their colour. This contrast is very strongly marked where the red Dewal portion of the Mari ridge forms one side of a deep khud, from which the gray ridges and spurs rise abruptly towards the peak of Chambi and the high summit of Murchpuri (9,229 feet).

Section along the Upper Abbottabad road.

The change in the geological structure of the ground is well seen by following the new or upper military road to Abbottabad from Mari station. Proceeding along this towards Sunny Bank Hotel, the reddish and gray sandstones and purplish red clays or shales of the Mari series, with south-easterly dips, appear in the road cuttings, one thin band of grayish-olive shale occurring among the reddish rocks below Titighar, and a little débris of a greenish color near to Sunny Bank. Just at the latter place nummulitic shales and limestone are nearly horizontal in the Kúldana road, more of the limestone and red débris being seen on a spur below it. The red beds are again to be found from this to the Kúldana cross-roads, just before reaching which

Sunny Bank.

At the distance above-mentioned and about half-way up the Khaira Gali incline, where the road bends westward into a steep ravine, it crosses a mass of red clays and greenish gray sandstones occupying a space of about 100 yards in width, and bearing traces of much crushing and displacement. Such dips as are seen bending towards the south-east at high angles and nearly vertical. The junction with the nummulitic limestones, &c., on either side is concealed by débris, the dip of the shales and limestones to the north-west being quite discordant, while those on the opposite side, though in the same general direction, are too distant to argue conformity therefrom.

5¼ miles.

This narrow band of sandstones and red clays strongly resembles, if it is not absolutely identical with, some of the Kuldana series: it may be traced from a spur close beneath KhairaGali, cutting through the limestone hills and khuds in a south-westerly direction along the flanks of the KhairaGali and Bhumkot spur to a place called Liran opposite to Clifden, where it disappears. Here, at Liran, it is overlaid by or associated with a considerable mass of stratified rock-gypsum of pinkish white colour, dipping, as the red zone generally does, in a south-easterly direction. Throughout its course it seems to be cut off by a fault from the limestones to the north-west, while its south-eastern boundary may very probably be another fault. The only fossils which have been observed are plant remains in the sandstones similar to those of the Mari and Kuldana rocks. The situation of this remarkable band apparently foreign to the local series, plunging into the lateral ravines and rising over the intervening spurs, marking a deep line of fault cutting through the limestone and shale series, bears testimony to the dislocation of the locality and may also be considered corroborative evidence of the nearly parallel line of abnormal junction between the limestones of the hills and the lower part of the outer tertiary series, coinciding with an extended region of faulted dislocation.

Beyond the place where the upper Abbottábád road crosses this red band, and thence to the crest of the spur at Bareán Gali (where there is another cluster of huts and bunnias' shops), black, compact, and lumpy nummulitic limestones and shales, varying up to several yards in thickness, may be observed. Their stratification exhibits as much forcible disturbance as before, and the prevalent dips are northerly at steep angles.

Bareán Gali.

Having here arrived at the crest of the first spur or ridge north-westwards from Mari, the situation overlooks on one side the profound Deval Khud, and on the other, deep ravines leading tributaries of the Haro river down from Chambi Peak. From a neighbouring eminence upon the ridge a view may also be obtained towards Mari, the deep khud beneath it and the col, or connecting spurs, at Ghora Gali uniting the Mari ridge with the limestone chain opposite, in the same way as the ridge and hill of Kuldana does. Down in the valley between these two connecting ridges may be seen the old road to Abbottábád descending the slopes and spurs from Mari beneath Nandkot and Clifden. This old road, like the new one, exposes a section in the cuttings, crossing the extension of the Kuldana limestone rib, and beds which ought to occupy nearly the same horizon as those immediately to the north of it at Kuldana. These beds, however, on the lower road bear only a general resemblance to the former section; red clays predominate, the sandstones differ both in quantity and kind, sometimes containing layers crowded with *Nummulites*. And the thick masses of greenish olive or gray shale of the Kuldana section are not seen. The ground seems to be much slipped and faulted; and down towards the bottom of the khud on the Mari side, this old road crosses several alternations of strong limestone and crushed red and variegated clays or shales, difficult to identify, except in a general way, with those at the northern end of the Kuldana ridge. Contortion, slippage, and local development might, however, easily account for the differences between the

Old road to Abbottábád, Clifden, &c.

two sections. The bottom of the khud, and for several hundred feet above it on the Mari side, as well as the whole of the opposite side (except at Liran previously mentioned) is of nummulitic limestone and shale, and the general dip of the section like that at Kuldana is to the south-east.

Bareán Gali.

Returning to Bareán Gali, the nummulitic limestone of the spur from KhairaGali into the Deval Khud may be seen passing downwards for hundreds of feet with a steep dip to the northwards, which, changing to vertical, turns in the side of the Masote glen so as to dip at a high angle to the southward. Far down in this glen the rocks contain nummulitic *Foraminifera*, but it is very probable that they are not all nummulitic, for southward of the continuation of the red zone cutting through this spur high up near KhairaGali, a band of hard sandstone was found, which may suggest that the limestones beneath it belong to some of the lower groups. One great inverted synclinal fold in the limestones far below this sandstone band is also visible in the side of this spur opposite to the steepest part of the ascending road from Deria Gali to Bareán Gali.

KhairaGali

From this latter place up to KhairaGali the road runs on the western side of the crest of the ridge; the same dark, compact and lumpy nummulitic limestones and shales being seen the whole way. The beds are much contorted, but near the barracks dip generally south-westerly, and further on close to the bazaar are inclined the opposite way at 60° to 70°. Just here another narrow red band, consisting entirely of clay sloping entirely in the same direction, passes through the bazaar and down into the khud to the westward; its relations are, however, very obscure.

KhairaGali to Changli Gali.

From Khaira Gali to Changli Gali there are two roads; of these the main one ascends on the west side of Chumbi Peak, and the other, or back road, generally in a dangerous state, only passable for men, takes the eastern side. A sketch section along part of it, with remarks thereon, will be found in Dr. Waagen's paper in Geological Survey Records, Vol. 5, p. 15. Following the main road upwards rocks of different age from those previously mentioned will be found, though some of the limestones are sufficiently like the nummulitic ones to escape anything but close scrutiny, and sometimes even this leaves them doubtful. The observation has been made that the nummulitic limestones may be detected by their bituminous smell; this is frequently, though not always, the case; but a better test seems to occur in the lumpy character, seldom long absent from the nummulitic beds.

These limestones and other rocks seen at intervals along the road have been referred from their frequently obscure fossils to the triassic and jurassic formations (see Dr. Waagen's paper just mentioned).

State of the rocks.

Something of the confusion among the rocks here may be gathered from the observation that within the short distance of about two miles from KhairaGali to Changla Gali by the main road, the jurassic beds re-appear seven times, the triassic four times, and the nummulitic three times; their places of contact being for the most part lines of fault or slip, of which fourteen or fifteen have been noted. The rocks are generally inclined at high angles from north-east and south-west axial lines; but even these are themselves inclined, and in places nearly vertical; the positions of the beds affording no help towards restoring the original arrangement of the curves or the relations between the different groups.

Jurassic.

For a short distance from KhairaGali nummulitic limestones and shales occur, their north-by-westerly dip rising from about 35° to vertical, steady in the limestones, but crumpled, crushed, and contorted in the shales; just beyond the vertical beds of limestone and separated from them by a slip or fault are some black shales much overrun by débris. They are probably a portion of the Spiti shales (jurassic) coming through from the other side of the hill.

The road turns round a small shoulder of the hill here, and a few paces beyond are some shaly limestones with a five-feet band of shales, underlying about 150 feet of hard dark-coloured ferruginous sandstones, shaly in their upper part. These dip at 70° north-west, and have been referred to the "Gieumal Sandstone," Upper Jura of Dr. Stoliczka, (see Memoirs, Geological Survey, Vol. 5, pt. 1).

Trias.

The road turns sharply here to the right, entering an open khud, and the next rocks seen are black and gray, strongly and thinly-bedded, limestones with some clay or rotten shale bands. The beds are steep, vertical, and bent over a nearly vertical axis. These limestones extend about 150 yards from the sharp turn mentioned, at which distance they have a strongly oolitic texture, overlying a thin-bedded zone. They contain a few fossils of triassic aspect. Although they appear to overlie the Gieumal sandstone and a few beds of the latter, with 5 feet of black shale both inclined towards the limestone, occur immediately beyond it, the junctions seem to be on lines of fracture and the limestone does not resemble the description of the cretaceous beds resting on the Gieumal sandstone series of Dr. Stoliczka.

Along with the small exposure of this sandstone and shale just mentioned are 100 feet or so of dark-coloured vertical limestone apparently belonging to the jurassic sandstone series, for a few beds of the latter, also vertical, are next seen, and a little further on, thin-bedded, black and gray shaly limestones are also nearly vertical or dipping at a high angle, north-west, indicating an apparent alternation of limestones in the sandstone series.

Here another fault brings into the section contorted and vertical, dark gray and gray, thick and thinly-bedded limestones, seen for 250 yards. They are occasionally interstratified with shaly layers, and are at the further end of the exposure oolitic. In these beds traces of fossils are not numerous, but the rocks appear to be triassic.

Jura.

Next seen is a mass of about 80 feet of vertical solid blue gray ferruginous sandstone calcareous in places and resembling that referred to the Gieumal series. It contains traces of fossils, which, however, could neither be extracted nor made out, and it seems to be enclosed between two lines of fault.

Trias.

Beyond this the road passes through vertical or highly inclined black and gray limestones, for 200 yards. They are partly thin-bedded alternating with shales, some are oolitic, and some largely composed of fragments of shells, among which are small oysters (one *O. Haidingerii ?*), casts of a large smooth *Bivalve* and of strongly ribbed shells, apparently *Trigoniæ*, also small *Rhynchonellæ* and some *Gastropods*. These are perhaps the most typical triassic rocks of the whole section.

Apparently brought into junction with these limestones by a reverse slip or fault, is a small quantity of vertical Gieumal sandstone, with some layers of black shale.

9th Mile.

Débris overshoots the bank for a short way, and at the 9th mile post, are gray sandy micaceous shales with limestone layers probably triassic, dipping to the eastward at 65° and other angles.

A few paces onward the dip changes, coinciding with a break in the rocks, and thin-bedded gray compact limestone which weather light yellow dip at 45° north by west for 100 yards. They contain beds full of small *Oysters*, and are believed to be triassic.

A very sharp turn in the road occurs here for another hundred yards, beyond which, gray, flaggy, and thin-bedded shales are seen, bent into bold curves, weathered of a light yellowish gray colour, and overlying some gray limestone occupying [illegible] in the beds. [illegible] fossils were found here, so that the position of the shales is [illegible] the rock for a few paces, protruding from which are some black rusty and [illegible] pisolitic shales.

Just beyond the last named beds nearly vertical nummulitic limestone and shales occur, the former having sometimes black filmy carbonaceous patches. These beds continue for 500 yards crossing the road with high northerly dips when not visibly curved. They contain pretty generally distributed—*Rotalinæ*, little spines, small *Nummulites*, *Corals*, and *Orbitoides*?

Nummulitic

Near the upper end of this exposure of nummulitic limestone superficial de[illegible] again, allowing however, some thick, bedded oolitic [illegible] to appear in contact with which some brownish [illegible] highly inclined to the northward contain numbers of canaliculate slender *Bel*[illegible] the arrangement of the rocks here, it is probable that the mass of nummu[illegible] included between faults on each side. Close to this place, but further up [illegible] thin bedded limestones succeeded by calcareous sandstone, over which is a [illegible] in parts very black and concretionary, resembling the Spiti shale of [illegible] except that no trace of fossils could be discovered in them. They are [illegible] the dark rusty Gieumal sandstone and are cut off by a fault from [illegible] and gray flaggy impure limestone with carbonaceous films [illegible] west by north at 70°. These beds contain a group 10 to [illegible] ments are closely compacted together. They are possibly [illegible] of these limestones is very earthy and flaggy, and [illegible] separated by a [illegible] nummulitic [illegible] the northward of west. At 9 feet up[illegible] black shale band, about 3 feet 6 inches thick, occurs, [illegible] which may [illegible] mentioned [illegible] miles) and Changligali the shales and [illegible] are to be seen, they present much contort[illegible] small *Rotalinæ* and little *Corals* of di[illegible] preservation.

Belemnites

Nummulitic

Changligali

From Cha[illegible]ulitic rocks predominate, but th[illegible] be triassic, and in two places nea[illegible]stone, and "Spiti shale" are seen th[illegible] each side of the 16th mile slab at a pl[illegible]

Here [illegible], *Belemnites*, *Pectens*, &c., and appare[illegible] of *Bivalves* (perhaps *Trigoniæ*) occur in san[illegible]. Besides these there are distributed through the ro[illegible] corals and beds largely made up of shell fragments in th[illegible]

Nummulitic [illegible] Dúngágali, again on top of Murchpuri [illegible] the road from Dungagali to Kálabág, [illegible] beyond which place, these rocks are seen almost in junction wi[illegible] stretching from Mianjani mountain, (the highest in this country, attaining [illegible] 10,000 feet) away towards the south-west.

Dungágali

Down in the botto[illegible] between Dúngágali and Kálabág, and also isolated at a much higher level under the [illegible] named post, there are some peculiar red beds the relations [illegible]hich h[illegible]t been worked out. They consist of bright red and purple clays, [illegible]blue and red-striped sandstones, variegated greenish and blackish purple [illegible] and a [illegible]f liver-colored and greenish clay or shale alternating with bands of [illegible] gray finely [illegible]ystalline gypsum and limestone. They extend for more than a mile down [illegible] valley of the Haro river, and at first sight seem allied to the gypseous [illegible]s of the Subathu group, but it is difficult to understand how these could have come into [illegible] position except by enormous faulting. It is perhaps possible that these rocks may [illegible] to some of those "*below the Trias*" of Sir Ban mountain near Abbottabad (see [illegible] of Geological Survey, Vol. IX, p. 335), but until a closer acquaintance with the [illegible]f the ground has been obtained, it is hardly safe to assign them to any particular [illegible]eir beds exhibit at least one anticlinal curve, and if normally placed, considering [illegible]ing character of the rocks along the Abbottabad [illegible] high above, they ought to [illegible]ition very far down in the series. They are ev[illegible]tly the rocks referred to in [illegible] paper to the Asiatic Society of Bengal, Vol. XXXV, as "Geyserian." [illegible]ng descriptions and Dr. Waagen's paper, it will be seen that the Chumbi [illegible]gali and the Abbottabad road, expose beside the nummulitic rocks two [illegible]ormations. Secondary rocks are also kn[illegible] to occur among the long [illegible] this higher region, passing northwards of Rawul Pindi; hence the [illegible]d at that a central mass of these rocks exists within the Murchpuri [illegible]ituations mentioned however are their exposures sufficiently [illegible]rtions regarding their conformity or otherwise, but it is very [illegible] Hazara (Memoirs, Geological Survey, Vol. IX, art 3) that [illegible] triassic series, while both of these and the num[illegible]ormable to the Attock slates.

[illegible] the whole district is the identity of some [illegible]n series examined by Dr. Stoliczka in [illegible]nestones and those of the Krol group [illegible]dia, Vol. V, part 1, and Vol. III, [illegible]ere and the Sub-Himalayan [illegible]

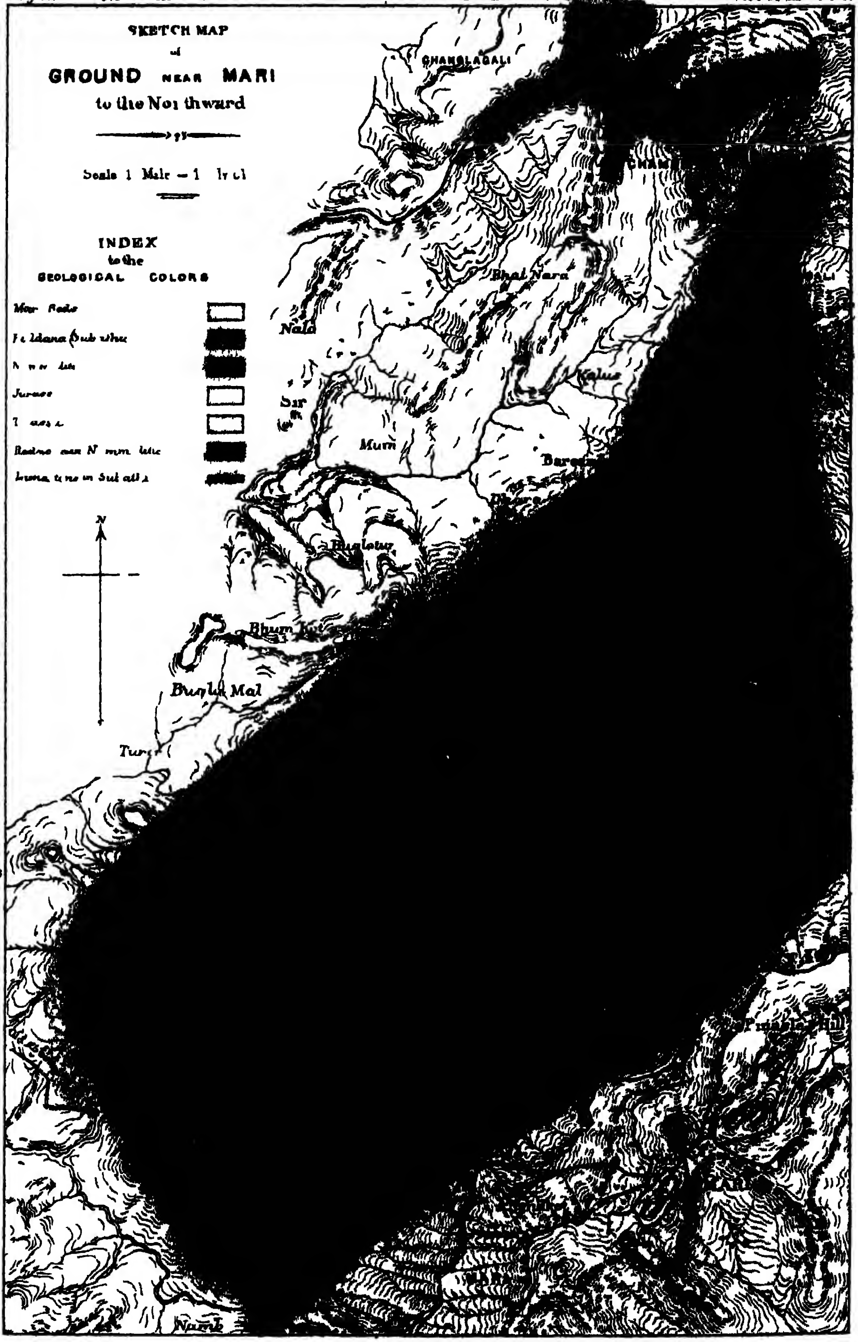
[illegible]B WYNNE

[illegible]

Six sl[illegible]

From [illegible]

Galena	...	...		
Argentiferous galena				
Antimony	...			
Tinstone	...	...		
Tin from ditto	...	...		
Massive iron pyrites		...		
Natural asphalt in clay		...		
Lava	...	...	...	[illegible] of the Colonial possessions


SKETCH MAP
GROUND NEAR MARI
INDEX
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GEOLOGICAL COLORS
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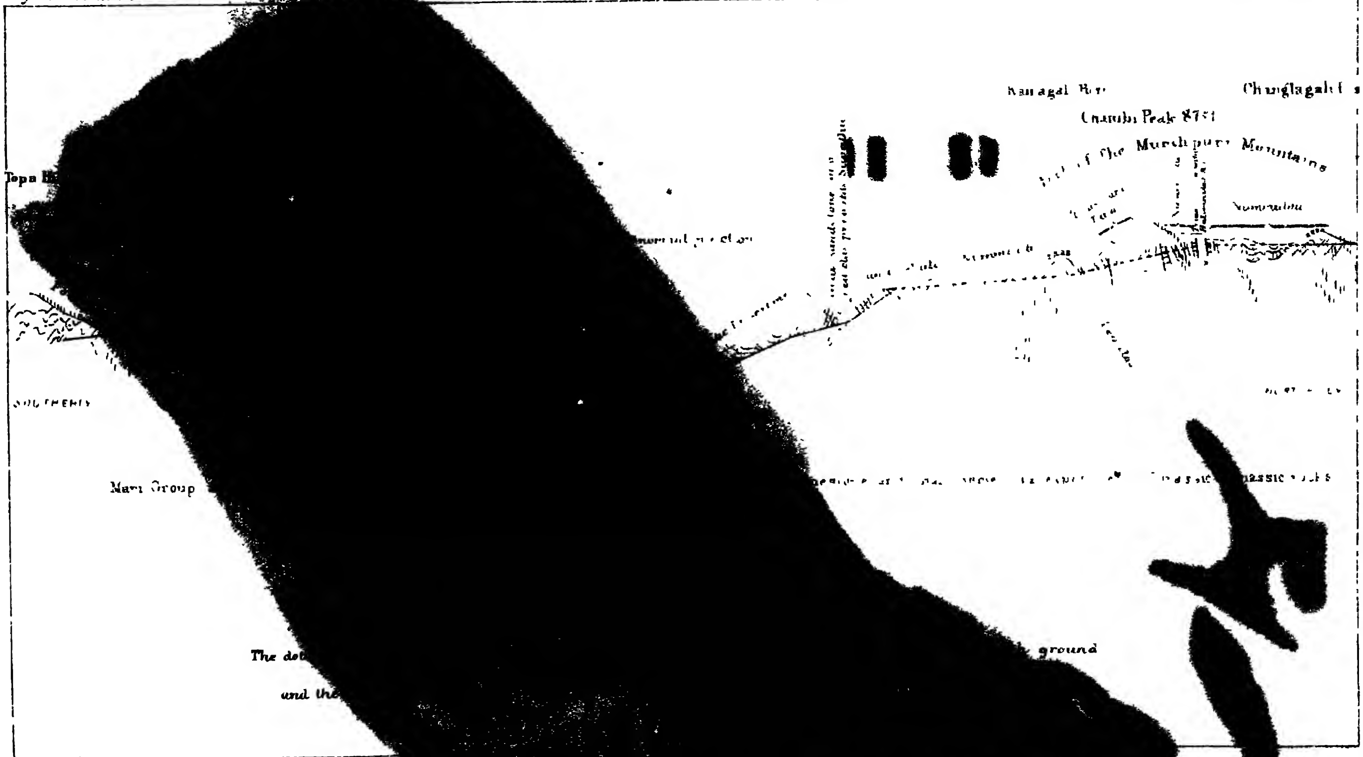
Wynne Section from Mari to Chungla[illegible] GEOLOGICAL SURVEY OF INDIA Records 1874



From the Australian Commission at the Vienna Exhibition.

Coal	Barnett river, Queensland.
"	Darling Downs, "
"	Victoria.
Coke	"
Chromic iron	Brisbane.
Manganese and iron-ore	Gladstone, Queensland.
Carbonate of copper, (malachite) ...	Cloncurry.
Antimony, (grey sulphuret)	loc,
Iron pyrites (mispickel)	loc?

Purchased.

Malachite	Russia.

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Archiv für Naturgeschichte. Jahg. XXXVII, heft 5, (1871), 8vo., Berlin.

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CONTENTS.

RECORDS

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1869. [February.

THE VALLEY OF THE POORNA RIVER. WEST BERAR; *by* A. B. WYNNE, ESQ., F. G. S., &c.

The Poorna valley between longitudes 76° and 78° east, is traversed by the 21st parallel of north latitude. It is about 124 miles in length from its upper or eastern end to where it passes into the larger valley of the Taptee; the main directions of both diverging at first so as to include an angle of about 50,° but afterwards becoming more nearly parallel or east and west. The width of the valley may be roughly estimated at from 30 to 40 miles on an average, but is in places greater.

Its boundaries are—on the south, the range of the Adjunta ghâts,—an abrupt scarp of the Deccan plateau produced, and gradually becoming less marked, to the eastward—some hilly and undulating ground forming the watershed in that direction between the Poorna and Wurdah valleys; and on the north, the lofty bold and varied escarpments of the Gawilghur range, which carry a high crest westwards near to where the Poorna river runs into the Taptee, the termination of the mountain range here sinking with some rapidity, though not being by any means abrupt.

The southern ranges pass imperceptibly into the usual steppe character of the Deccan, while the mountains on the north are a complex mass or group with a generally east and west extension, and such summit elevations as 3,595, 3,778, and 3,975 feet, declining gradually northward into the valley of the (upper) Taptee.*

These Gawilghur mountains are intersected by steep glens and wider valleys, sometimes presenting nearly vertical precipices of great but unmeasured height which may in places reach 1,000 to 1,200 feet. The glens and ravines wind intricately among the mountains, affording some very fine scenery, and as their streams seldom retain water for any considerable time, the wildness of this is increased by solitude.

The valley of the Poorna possesses but little variety of geological interest and is principally distinguished by monotonous repetitions of features observable in crossing the Deccan from the seaward to this locality, where each hill and ghât and undulating slope or plain exhibits similar kinds of nearly horizontal flows of gray amygdaloidal trap, with here and there a bed of harder texture of columnar structure, or of bright red bole, or alternations of these; the traps sometimes containing numerous zeolites.

In the river valleys, and where superficial 'rain-wash' has accumulated, a light brown 'kunkury' alluvium is associated with calcareous sub-recent conglomerate below and black cotton soil above, one being quite as occasional and accidental as the other, the conglomerate or concrete being perhaps the most persistent along the river courses, the brown alluvium or (?) "soda soil"† more universal and the cotton soil occurring, subject only to the rule that it is always uppermost.

Upon descending the escarpment of the Deccan into the valley of the Poorna its alluvial plain is entered, often at no great distance from the ghât, and stretching away as far as can be seen; only clear days permitting some of the nearest mountains upon the opposite side

* These heights are taken from a small photograph copy of a map of Gangra by J. Mulheran, Esq.

† This efflorescing brown alluvium is considered by Mr. Blanford different from the "soda soil" of Madras.

to become visible. Heights not being given upon the best maps obtainable, the elevation of this plain and its boundary ranges could not be ascertained even approximately in the absence of a barometer—which is to be regretted, as the main watershed of India separates the sources of the Poorna from those of the Wurdah, the water of the former being discharged eventually at Surat whilst those of the Wurdah are tributary to the Godaveri, which enters the sea below Rajahmundry on the opposite side of the peninsula.

The alluvium of this great plain, although of very considerable depth and occupying so large an area, is as completely isolated from that of the neighbouring rivers as such a deposit can be said to be. A section crossing the valley from the Adjunta ghâts, by Edulabad across the Poorna river, to the western termination of the Gawilghur range, would show the ordinary trap of the Deccan, forming the high ground at either end, and an undulating country between, which viewed from above or from a distance has a plain-like aspect, but frequently exposes the rocks of which it is formed; consisting of the usual traps, here and there covered only by slight detrital accumulations of the same kinds as those of the Deccan. Except on the very banks of the Poorna no considerable quantity of alluvial matter would be found, and this does not extend far from the river at either side. North and south through Mulkapoor a different section would be obtained. Here a wide space, chiefly on the south side of the Poorna, is occupied by fine brown calcareous alluvium with 'kunkur' and is connected by a narrow neck, at Peeprala, with the great alluvial deposit of this valley which in thickness may exceed 150 feet; and nothing else, save varieties of this, is to be seen in or near the river from Dadulgaon on its south bank eastwards up the stream nearly to the "sungum" or junction of the Phairlee river, which enters the Poorna near Kowsa, if we except two or three small exposures of trap in its bed near Peeprala Pulsoad and about three miles west of Burra Golagaon. The Poorna changes its course from the N. N. E. at the junction of the above-named tributary, and thence takes a westerly direction:—the alluvium on its south side seldom extending beyond an average of ten miles from the river and nearly coinciding along its southern boundary with the Nagpoor extension of the Great Indian Peninsula Railway—while on the north it reaches nearly to the base of the mountains. On the east its rather arbitrary and more or less indefinite boundary closely approaches the watershed east of Ellichpoor and bending southward traverses undulating country eventually reaching the flanks of the hills near Oomrawuttee.*

All round the margin of this alluvial tract is a belt of country that might or might not with propriety be included within it, although the surface-deposits there do not conceal the underlying rock, the exposure of which was taken as the chief guide in determining the line of boundary. On the north and east, this tract of country is very stony, though nothing resembling an old beach is seen, and it may be supposed that streams descending from the mountains and hills have frequently travelled across this space, their courses subject to lateral deviation, covering the whole of it with the coarser fragments brought down by floods at a time perhaps when the water of a lake or the sea, occupied the basin of the finer alluvium and arrested the boulder-bearing velocity of these mountain streams.†

In every part of the alluvium calcareous conglomerate or concrete is of common occurrence. It occasionally contains fragments of bone or fossil teeth of ruminants, but although sought for, no large accumulation nor even a large fragment of these fossils, was observed. Yet enough was seen to show an identity of the conditions under which these deposits and those of the Nerbudda valley were formed. This sub-recent conglomerate‡ is very frequent in the stony tract above mentioned. It was everywhere searched for worked flints but without success, although one flake was found in a quite similar deposit, forming the right bank of the Godaveri at Pyton in the Deccan, at a considerable distance to the south.

Small land shells are not uncommon in the alluvium, some were preserved and transmitted to Calcutta, but in general they were too fragile for removal. They appeared to belong to existing species. Specimens of *Melania tuberculata; Paludina Bengalensis; Bithinia pulchella; Lymnæa—; Planorbis—; Unio (?) favidens: U.—?* have been recognized.

* Pronounced Oom'rowtee.

† At one place in the stream near Dhanapoor the stony margin seemed to unite with the finer alluvium by alternations of coarse and fine strata two feet or so in thickness.

‡ The native name for this 'concrete' is "Khrruk."

A deposit of varying thickness (within three feet) and but small lateral extent, consisting of fine dazzlingly white sand finely laminated occurs in the alluvial bank of the Poorna at Paruth. It appears to be composed of comminuted or disintegrated crystals of felspars with a small admixture of clay. It did not appear to be formed of or to contain minute organisms, such as foraminifera, and was not elsewhere observed.

Much of this Poorna alluvium produces efflorescences of salts, of soda chiefly, and in many places the wells sunk in it are brackish or salt. Over a wide tract on each side of the Poorna river, north of Akola and thence eastward towards Oomrawuttee, wells are specially sunk for obtaining common salt from highly saturated brine.

Some of these salt wells near Dyhunda in the lands of Gunoree are from 120 to 130 feet in depth or probably more. They are sunk through yellow clay, then redder clay, and below this a coarse sand or fine gravel from which the water issues with great force. They are lined with wicker work in order to preserve the pottery vessels, in which the water is raised by hand, from breakage. The crystals of the salt are small and it is rather dirty, but during the "dhūp kâla" or hot season, it can be obtained whiter. The wells are numerous over the tract north of the river and some also occur to the south.

That the alluvium of the valley is of considerable depth may be perhaps inferred from the absence of numerous exposures of rock, as well as from the depth of nullahs and height of the river cliffs. The conglomerate, as usual, occurs in its lower portions, but was observed in some places west of Patulla at different heights in the sections exposed. Its constant or frequent occurrence beneath the rest of the alluvium would not prove its being contemporaneous in all places, as the trap rocks, upon which these deposits lie, cannot be presumed to have had a surface sufficiently even to have permitted this.

Whether the whole of this alluvium was deposited in a lake, or by the river travelling from side to side of the valley under other conditions than at present obtain, does not appear. A former estuarine state of things may be indicated by the salt-bearing gravels, or a large salt lake, but the even though interrupted surface of the alluvium is against the probability of its having been deposited by the Poorna under present conditions; while want of information as to the relative levels, obscures the possibility of determining whether the rocky country about Edulabad may not have formed a natural *bund* flooding the country occupied by the alluvium; certainly the stream through most of this is sluggish, but it seems to be a rather strong assumption, that no greater fall than the height of the river banks where it enters this rocky tract—perhaps on an average not more than 30 feet—takes place within so great a distance as extends between this and the upper end of the alluvium, about or S. W. of Oomrawuttee.

Good water is scarce in this district, in some places shallow 'jhieries'* alone can be depended upon for a supply, the wells being brackish and even the river gravels furnishing brackish water if pierced to any considerable depth. A succession of dry years seems to have greatly reduced the usual supplies of water, and very many of the villages among the hills to the north are deserted, it is said, because the streams which supplied them formerly do not now furnish sufficient water. Not improbably the diminution in the supply has been caused by the wholesale cutting down of the jungles which covered the country before the period of the English Raj.†

The hills and portion of the valley south of the Poorna river have been stated to consist of trap similar to that of the Deccan; all the usual varieties of amygdaloid, zeolitic, columnar, hard, gray, and softer, ashy-looking traps occur, their stratification being very perceptible, and always nearly horizontal.

* This name is applied to small excavations in the sandy bed of a river reaching the water which trickles beneath the surface, and thus becomes naturally filtered.

† Want of water is much complained of at Chikulda. There seems to be no reason why the plateau to the east of the bungalows should not afford a sufficient catchment basin for the station. As the trappean strata of the hill dip N. by W. at 5°, if wells were sunk, the north side of the plateau would be the position to choose with most probability of success. Near the bungalows however the plateau, if such it can be called, is very narrow, and affords a much smaller catchment area, yet even here the hill must contain strata which retain water as it issues from the rocky beds of nullahs, and one well immediately beneath the northern edge of the plateau, and at a considerable height upon the mountain side, is stated never to go dry.

About the Gawilghur range on the north there is a constant dip at low angles in that direction, the lower part of the range being chiefly composed of amygdaloid and soft traps; and hard basaltic beds occurring in greatest quantity among the higher parts of the hills, where such bands may be seen to course along the sides of cliffs and mountains for several miles; a capping of the harder trap remaining here and there on top of an isolated peak or hill, while lower elevations around have less angular and more flowing outlines, being formed of the softer varieties of the trap.

Occasionally along the base of this range, the beds have been thrown into wide curves with very gentle inclinations, their axes dipping but slightly to the northward.

Intertrappean beds are said to occur among the Gawilghur hills; they were only detected in one place, and consisted of hard chert enclosing numerous shells: but though near, this is not properly speaking within the Poorna valley.

Perhaps the most interesting geological feature of this country is the occurrence of a great fault, with a down-throw to the south, which may be very considerable, as it shifts the trap downwards for some two or three hundred feet visible, added to an unknown thickness of the trap which is buried by it, so that trap, of what exact horizon cannot be stated, is brought against the underlying Mahadeva or Bâgh (Tanda)* sandstones. This fault crosses the country in an east and west direction, close to the foot of the Gawilghur range north of Ellichpoor, where the abrupt southern scarp of the range shows these sandstones, occupying the interiors of open curves in the trap like those just now mentioned. The difference of inclination between the sandstone and the traps is but slight, so that their unconformity is, as usual, not very strongly apparent, though it nevertheless exists; the line of contact where the overlying traps rest upon the sandstone, is frequently difficult to see when close by it, though from a distance the difference of coloring and the bold projections of the sandstone outcrop mark it well. The sandstones are chiefly soft or coarse white and even-grained rock, which would doubtless make a good building stone. A large mass of these occurs in the lower portion of the group exposed; above them are conglomerates, other sandstones of similar kind, purple and black shales and flagstones, variegated and white flagstones and shales, and then solid gray limestone with silicious or cherty nodules of peculiarly rugged aspect; these limestones in some places becoming so variegated as to form what if polished would doubtless be a handsome marble.

In this group of Mahadeva or Bâgh beds dips to the north of 10° and 15°, with others more nearly horizontal, may be sometimes seen; these becoming less as the sandstones finally disappear beneath the Gawilghur traps to the north of the cantonments of Ellichpoor. In the river at Nurrha, north-east of the latter place, the section is somewhat unusual. The ground here seems to have been intensely faulted, and instead of leaving the trap and passing over the fault on to sandstone at the base of the hills, trap is again found north of the general line of fault; then occur several large dykes of another intrusive trap different from that usually met with, between which are masses of the limestone, sometimes resting upon a conglomerate, and tilted in various directions at angles of 35° and 50.° Beyond this disturbed locality the next rock seen is sandstone, horizontal for some distance but soon overlaid and covered up from view by the unconformable trap.

In the flaggy portion of the Mahadeva or Bâgh group, impressions of large plants have been observed, and in the shales and some of the limestones numerous small univalve shells.

Fossils were known to have occurred north of Ellichpoor, as mentioned by Dr. Bradley. These sandstones were known to the late Rev. Mr. Hislop, but seem to have been erroneously considered inter-trappean. Lithologically they frequently recalled the appearance of the sub-trappean cretaceous rocks of Bâgh-Tanda and Rajpoor along the Hutnee river. &c., in the valley of the Nerbudda, and it was a disappointment not to find the same, or the same quantity of fossiliferous evidence here, the beds in both places being possibly, or probably, of the same age.

Laterite occurs on the new road from Ellichpoor to Oomrawuttee at a place called Bulgaon or Burgow, about six miles from the latter city. It is more properly a lateritic conglomerate of small pebbles cemented together by iron oxides. It lies horizontally, and has

* Bâgh-Tanda is the name generally used by people when speaking of Bâgh at a distance therefrom.

much the appearance of a re-composed rock, in many places quite incoherent, harder at the top and outsides than internally, and the pebbles are all red, bright purple or ferruginous, glazed outside and not recognizable as derived from any of the traps of the country, unless from their resemblance they might be taken to have come from one of the beds of red bole, which are not very uncommon; but then there is no reason why if so derived they should not be intermixed with other trap pebbles. This has all the appearance of a local deposit, does not crop out in some natural excavations near at the same level, and apparently passes away underneath the cotton soil, but being horizontal or nearly so shows for a considerable distance along a sluggish stream which occurs here, occasionally varying in structure so as to become a mottled white and purple rock of some strength.

In one place on the bank of this stream a little cliff shows the incoherent gravel resting upon a soft ferruginous bed, about 9 feet thick, with some lines like those of deposition. Beneath this are 5 or 6 feet of greenish-gray trappean mudstone, very splintery and breaking up into cubical forms so much that it is nearly impossible to obtain a fresh fracture; some harder parts seem calcareous, and have a fracture resembling that of compact limestone. The laterite may be traced for more than a mile in an east and west direction. Near Budja Kaira, on the larger river here, strong vesicular laterite undulates about horizontally, but does not continue down the stream.

Again at Reethpoor lying to the eastward from Oomrawuttee, there is a quantity of laterite in low swelling undulations—with the usual appearance of lateritic ground, a ferruginous more or less smooth surface and occasional hard projecting knobs, but no good sections of the rock.

At Chickulda (the hill station on top of the Gawilghur range frequented by people from Ellichpoor), the plateau upon which it stands and the surrounding summits have a strongly lateritic appearance such as may be seen at Matheran and other summits of the Western Ghâts.

These indications of laterite, occurring as they do in situations where the uppermost beds of the trap series might be supposed to occur, may indicate a similar or nearly the same lateritic horizon, which is known to occur among the uppermost, if not actually on the top of, the Deccan traps along the Western Ghâts. Otherwise they may be referrible to zones of ferruginous strata more specially lateritic than the layers of red boley trap referred to as occurring in this neighbourhood and on the Deccan plateau; but their limited development and isolated character hardly afford sufficient grounds to reason upon with much probability of arriving at trustworthy conclusions.

The cotton soil or black soil of the Poorna valley, although common enough, as is usual in these trappean districts, has no geological peculiarity here requiring attention. To its development, however, and the fertile nature of soils derived from the trap may be traced doubtless the name which this country has obtained as a cotton-producing district.

On the Kuddapah and Kurnool Formations: *by* W. King, Junr., B. A.

The rocks forming the greater parts of the Kuddapah and Kurnool districts in the Madras Presidency have been long known through previous explorers under the names of "Diamond Sandstone," "Clay-slate Formation," &c. They extend over such an immense area, and are found to be so complex in their stratigraphy and so diversified in their relations, particularly among the lower and older groups, that their systematic survey is not yet quite completed, though some years have already been spent in their examination. Sufficient, however, is now known of them to warrant the giving a short sketch of this interesting series of rocks.

The series consists of great thicknesses of quartzites (altered sandstones), slates, trap-flows and their associates, and limestones; and these are found to constitute two (if not more) great and distinct formations. To the older, being so typically and largely exhibited in the Kuddapah district,* the name Kuddapah Formation has been assigned; while the newer Kurnool Formation derives its appellation from the adjoining district over which it is so very well seen.

* Kuddapah town itself is on shales and limestones of one of the groups in the newer formation.

The area of these rocks, from the Kistnah river down to Naggery Nose,* their southernmost extremity, is about 13,500 square miles. The greatest thickness of each formation, as at present known, is:—KURNOOLS, 1,200 feet; KUDDAPAHS, 21,000 feet.

The most interesting feature about these formations is that they are most probably representatives of the great VINDHYAN series of Indian rocks. This conclusion has been arrived at from careful comparisons of typical rock-specimens from either series, and of the recorded observations made during the surveys of each. The VINDHYANS have now been traced as far south as the Godavery river, where it traverses the district bearing its name; and here they are so lithologically and stratigraphically like the KUDDAPAHS and KURNOOLS on the Kistnah river, not very far south, that there hardly remains a doubt as to the identity of the one with the other.

The history of the KUDDAPAHS is still to be thoroughly worked out; and on this account, the present sketch will be more directly confined to a description of the KURNOOLS. There are, however, some well-marked and clearly made out features of the KUDDAPAHS which may in the mean time be adverted to.

Both formations agree in this, that they are largely made up of buartzites, while limestones are sparingly developed in one and extensively in the other; but the KUDDAPAHS are distinct in showing strong groups of clay-slates, with one of which it may be necessary eventually to include the trap-flows and their associates referred to above.

Supposing at present that all the quartzites, slates, &c., not included in the following description of the KURNOOLS, may be considered as of the KUDDAPAH FORMATION, it is then possible to give an idea of their locality in the great area of country occupied by this formation.

The Goolcheroo hill-ranges south of Kuddapah, and their extension south-eastward down to Triputty and the Naggery hills, are made up of quartzite sandstones and conglomerates; while rocks of the same kind with bands of slate go to form the long range of the Eastern Ghats or Yellacondas lying between the Kuddapah and Nellore districts. The country south-east of Kuddapah, that is Ontamitta, Chitwail, Poolumpet, &c., within these mountain ranges, and that due north of it:—Nullamullays, Budwail and Cumbum, up to the Kistnah river, are also made up of like rocks of the same formation. The Gundicottah range of hills, north-west of Kuddapah, is likewise of these old quartzites, and the parallel ridges and valleys between that range and the Bellary district to the west, with their extensions right up to Jaggarnat-Conda (hill), a few miles south of Kurnool, are of quartzites, slates and traps.

These older rocks are interesting as being traversed, at rare intervals, by veins and strings of copper and lead ores, accounts of which have from time to time been given by writers on the resources of Kurnool and Kuddapah. Copper ore occurs very sparingly; in fact, there are only traces of it, but the sulphide of lead is more abundant. The workings for both were abandoned years ago; a state of things perhaps due to the difficulties in the way of living at, and working the mines, rather than to a failure in the ore. Traces of these ores are also known in the older crystallines or gneiss, of the remainder of the districts.

With such a brief account of what is at present known of them, the KUDDAPAHS may be left for future description.

KURNOOLS.

This formation unfolds itself as a double series of groups of limestones and quartzites; the lowest beds of all being quartzites, as thus, in descending order:—

1. Limestone group ..	...	a. Calcareous shales. b. Limestones.
2. Quartzite group ...	...	a. Pinnacled beds. b. Plateau beds.
3. Limestone group ...	...	a. Non-calcareous shales. b. Limestones.
4. Quartzite group ...	...	a. Massive beds. b. Beds (containing diamond gangue).

* A peak of the Naggery range, about 40 miles W. N. W. of Madras.

These four groups are quite distinct, though conformable; they generally overlap each other in some part of the field, and they lie, for the most part, very much as they were originally deposited, viz., in great flat basins with edges slightly turned up,* or in very flat undulations, from which, however, the upper limestones are always denuded, leaving the quartzites exposed.

1st Group, Khoondair Limestones.

The uppermost group lies nearly all over the wide Khoond-air (river) valley which stretches northwards from Kuddapah town, and over most of the Kuddapah basin or southern extremity of this valley. There is a small outlier under the fort of Kurnool; while more of the same rocks cover the eastern extremity of the Raichoor Doáb. Again, a considerable detached area of these beds, with the other groups, occurs in the Palnád, or western taluqs of the Kistnah district.

The rock coming to the surface,† especially in the Khoond-air valley, is not, however, always limestones; more generally, there are reddish-purple calcareous shales (occasionally cleaved), and these constitute the upper member of the group. For instance, the shales occur all up the middle, and very strongly at either end, of this great valley. They gradually shade down into the typical limestones of the group, which are dark-gray, more or less earthy, sub-crystalline beds; sometimes very massive and thick, oftener flaggy or easily split up into flags of 1—3 inches in thickness. The limestones are also occasionally more crystalline and compact, and cleaved to a certain extent, where folding or crushing of the beds has taken place, as along the eastern side of the Khoond valley. They of course show most along the skirts of the valley, as near Kuddapah, Podatoor, Dhoor, Chagalmurry, Sirwél, and so on up to the banks of the Kistnah.

2nd Group, Paneum Quartzites.

Along the western side of the Khoond valley, the country rises very gently in a series of low long-sloping hills, with a few plateaus and undulations, which finally present an irregular scarp towards the Bellary district. These are the Gundicottah, Ramwarum and Paneum hills, whose surfaces, with the exception of the Gundicottah range, are made up of quartzites of the second group, which thus rises up from under the limestones of the Khoond valley.

This is the only side of this part of the country over which these quartzites occur; they do not appear on the western side of the valley, for the group thinned out altogether in that direction, as well as to the north and south; the sections among the turned up strata on this side showing the upper limestone group lying on the lower one without any intervening quartzites, as is the case in the sections on the western side.

Altered sandstones of the same group show rather strongly in the Kistnah district; where they are again, through the denudation of the upper limestones, the superficial beds of the low hills in the south-west corner of the Palnád.

The quartzites are of two kinds, quite distinct enough as features in the landscape, but hardly sufficiently so to be referred to as separate members of a group. The upper variety is a thick-bedded, massive, compact, white sandstone, much vitrified, but granular, and showing a very peculiar style of weathering into massive buttresses and pinnacles. The strata are generally horizontal, or at a very low angle, and the steep-sided ravines and scarps denuded in these are often fringed with strangely picturesque masses of rock, or the slopes below the scarps are strewn with great fallen masses of the same beds. The high-road from Kurnool to Nundial passes over a plateau of those white quartzites, and the quaintly worn masses immediately remind one of some rocky coast from whence the rushing and tumbling waters have long since retired.

Coarse sandstones and grits, with pebble beds, of dark colors, and in thinner strata are generally found subjacent to the thick, white, pinnacled quartzites, and are often alone without the covering of the upper beds. In such last cases, the remaining beds now form the summits of a number of flat-topped hills fringing the Koilkoontla and Banaganpilly sides of the Khoond valley.

* The subjacent Kuddapahs are, on the contrary, turned up on end, convoluted, crushed, and faulted in the most varied way.

† The Khoond valley is very extensively covered with cotton soil.

3RD GROUP, JUMMULMUDDAGOO LIMESTONES.

Wherever the above group of quartzites has been cut through, it is seen to be resting quite conformably on a thick series of shales and limestones; occasionally the shales thin out and nearly disappear altogether, and then the quartzites look to be resting directly on gray limestones.

These constitute the second limestone group among the KURNOOLS, and they are generally easily distinguishable from those of the Khoond valley. The shales are generally of a buff color and are never calcareous, while the purple shales of the upper group are always more or less so; and again the limestones are as a rule more crystalline and compact. There are, it is true, just as earthy and flaggy beds to be found in the upper as in the lower group, but such beds are less frequent in the latter, and they are arranged in definite succession. There is generally a three-fold series, thus:—at the bottom, compact, sub-crystalline gray, and some purplish beds, with a thin series of peculiar limestone breccias; in the middle, thick, compact-splintery dark-gray and blueish beds; and thirdly, pale and dark-gray compact, sub-crystalline and sub-earthy, often flaggy, beds.

The more crystalline and compact beds weather in a peculiar coralloid manner; the worn surfaces being so radiately furrowed, pitted, and concentrically terraced, that the rock seems to be made up of two or three different forms of coral; but close examination has failed to show any organic structure. This coralloid appearance is characteristic of any great show of these lower limestones, though the same feature is also seen every now and then in the upper group.

This generally more crystalline set of limestones is seen at intervals, along the eastern side of the Khoond valley, in a narrow belt of outcrop at or near the western base of the Nullamullays. Again, on the western side of the same valley in Koilkoontla and Banaganpilly. and in the valley between the low Nosoom ridge and the Gundicottah hills, and so further south, in the western part of the Kuddapah basin, where the Nerjee quarries* have been opened up in the thin and compact beds of the group.

In the steep western slopes of the Gundicottah, Ramwarum, and Paneum ranges of hills, these limestones again come to light and form a narrow continuous terrace below the vertical scarps of upper quartzites, all the way from the tops of the hills east of Tadpurthee (Bellary district), up to within 24 miles south-south-east from Kurnool, when it spreads out in wide sheets between the lower and gentler undulating hills which are here sinking down to the flat country of Kurnool, itself built on a further out-stretch of these same beds.

Here, in Kurnool, the group has thinned out a great deal, but still there are the three varieties of limestones in their proper order: the canal being cut in thin flaggy upper beds; the more crystalline strata cropping out between the canal and the village of Calloor; and the thin grey compact sub-crystallines, though altered much by local igneous action, showing close under the western bastions of the town. Thence, with the exception of some slight denudation in the Toongabudra and Kistnah, these limestones extend northwards to a few miles beyond the latter river, in the Hydrabad territory.

In the Palnâd there is the limestone again in great force. It here presents identical characters with those in Kurnool and Kuddapah, except that it is more extensively cleaved; and that the white and buff non-calcareous shales are only seen to a small extent.

4TH GROUP, BANAGANPILLY QUARTZITES.

Lowest of all of these strata comes another quartzite group which is interesting as including the beds from which only diamonds are known to have been extracted in the districts under description.

Hence, if the old nomenclature of "diamond sandstone," or "diamond formation" was to be employed in a classification of Madras rocks, it would have to be applied to the KURNOOLS, or one of the groups included in that formation. There is no case known of diamonds having been found in quartzites of the KUDDAPAHS, or in fact in any other group of

* These quarries were opened, and are now extensively worked by E. W. Barnett, Esq., who has used the stone whenever practicable on the Madras Railway, and for the new Madras University and other public buildings in the Presidency.

quartzites but the one now described. It is not, however, advisable to employ a name to distinguish a formation, which is derived from what is evidently only an accidental attribute of the rocks; while it is not certain that the diamond sandstones of Punna in Central India, which belong to the VINDHYAN SERIES, are on the same geological horizon as the diamond-bearing beds in the KURNOOLS.

This group of quartzites is a generally thin series of coarse sands, grits, and pebble beds, of dark colors; the sandstones being in thick beds, while the grits, &c., are generally thin and sometimes flaggy. The pebble beds are full of small fragments of chert of various colors which are evidently derived from the slates and trappean beds of the KUDDAPAHS, on the up-turned edges of which they now rest.

The relations and constitution of the group were first made out at Banaganpilly in the Kurnool district, where the long sloping hill which rises to the west of the town is faced with the quartzites.* From this point the strata were traced to the west, on either side of the Puspulla valley, as another narrow terrace of nearly horizontal beds of not much thickness, below and continuous with the terrace of limestones of the second group, already referred to as lying below the western scarps of the Ramwarum and Paneum hills. Indeed, these lowest quartzites form the toe of these western slopes.

The thin-bedded pebbly strata which are generally the lowest in the group seem to be the holders of the gangue, or shaly seams, in which the diamonds are found, but it is only at rare intervals in the exposed area of these pebble-beds that workings have been opened, which is partly accounted for by the fact that these seams of sandy and pebbly shales are only of local occurrence in the quartzites. The selection of working sites seems mainly to have been guided by chance, as the finding of a diamond by a cooly or shepherd, and the selection has been a lucky one in only some cases, for there are localities where extensive workings have evidently been carried on for centuries; while others have soon been deserted. The diamonds found at present are very small and not of much value, nor do the returns seem to have been any better for many years. The workings are of two kinds; mines excavated in the strata, or pits sunk at various points in the recent deposits of dèbris, shingle, and gravel, derived from the denudation of the quartzites.† The Banaganpilly workings are mainly mines, while the now deserted pits at Chennoor near Kuddapah were in recent gravels.

In the Palnad,‡ there are again a set of altered sandstones answering to this group, and there too among these beds are frequent traces of old diamond workings.

The lowest group of the Kurnool formation is always found to be resting unconformably on other quartzites, slates, and limestones; and where it is overlapped by the superincumbent limestones, these in their turn are found covering the older rocks in the same way; in fact, there is not the smallest doubt but that the four groups now described constitute a distinct formation separable by a great interval of time from the subjacent strata, or the KUDDAPAH.

Both formations are totally devoid of any fossil remains, at least not a trace of evidence of organic life has been found in their strata, and in this they are like the VINDHYANS which are as indicative of a period when there was no life. No more likely series of rocks for containing such remains could be imagined; and one is tempted again and again to examine favourable localities, but always with no other result than some deceptive concretions, or worm-like tracks, or the most perfect surface of ripplings in the sandstones.

Neither can it be that fossil remains which may have once existed can have been so completely obliterated by the metamorphic influence to which these rocks have been exposed, as to have left no trace behind; for whenever we have the originally sedimentary contritution of the rock apparently completely baked out of sight, as it were,—as in the case of pebble beds and the coarsest conglomerates, which, until they are weathered, are as uniformly granular quartzites as one could wish to see—, the various weathering influences have again revealed the original constitution.

* The Banaganpilly diamond mines are sunk and worked on the slope of this hill.

† These dèbris-deposits are often quite outside the area of KUDDAPAHS and KURNOOLS, and hence we occasionally hear of diamonds being found in the neighbourhood of granite, or gneiss, when they are supposed to be derived from the latter rocks.

‡ It may be as well to notice that the so-called Juggiapett coal-field is a north-easterly extension of the Palnád area, and the Juggiapett rocks are KURNOOLS and KUDDAPAHS which are not at all of a coal-bearing character.

There are deceptive appearances of organic structure, such as, minute concentrically laminated globular bodies, in some of the KUDDAPAH rocks; the coralloid character of the Kurnool limestones; minute *Cypris*-like bodies in the upper limestones; the dendritric crystallizations of the oxide of manganese in quartzites, limestones, and slates; and lastly the cavities of clay-galls so frequent in the sandstones; but these of course are all referrible to other than organic origin.

GEOLOGICAL SKETCH OF THE SHILLONG PLATEAU: *by* H. B. MEDLICOTT, F. G. S., Geol. Survey of India.

The main features of the geology of the Shillong plateau, on the north-eastern frontier of Bengal, have been known for some time: cretaceous, nummulitic, and younger strata, resting horizontally upon metamorphic rocks of various types, at an elevation of 4,000 to 5,000 feet, and doubtfully related to extensive masses of trappean eruptive rocks. A brief opportunity has recently occurred of visiting the hitherto geologically unexplored western portion of the plateau in the Garo region; and also of re-examining the central portion, in the Khasia district, *at a season when field work was possible.* A brief abstract of the results is here given in anticipation of the more detailed description.

Regarding the supra nummulitic rocks, which are very poorly exposed in the central region, little fresh information has been gained. From the sandstone of Nongkalong on the western limits of the Khasia district, where it rests upon nummulitic limestone, Captain Godwin-Austen has made a collection of fossils upon which Dr. Stoliczka remarks that "none of the species, so far as recognizable, appear to be identical with those known from the nummulitic beds of the same district."

The nummulitic formation presents a total change in the character of the deposits from east to west: from being purely sandy and calcareous, they become almost entirely argillaceous.

The doubtful horizon between the nummulitic and cretaceous formations has been worked out. The former does not overlap the latter; the northern outliers, so far as known, are all of the cretaceous deposits.

The local order of the cretaceous deposits at Cherrapoonji is described.

Many of the fossils collected have been identified by Dr. Stoliczka with forms occurring in the Ootatoor and Arrialoor groups of the upper cretaceous rocks of South India. In the small collection obtained, there were recognisable eleven forms of Cephalopoda, twenty-seven of Gastropoda, eleven of Lamellibranchiata, three of Brachiopoda, and four Echinoidea.

A very extensive formation of stratified eruptive rocks is exposed, unconformably overlaid by the cretaceous strata and resting in natural junction against a steep face of the metamorphic rocks along the south base of the plateau. It is fully 3,000 feet thick. No inter-trappean sedimentary rocks, nor any infra-trappean younger than the metamorphics, having been found, it is impossible to assign the age of this eruptive formation. It is proposed to call it the Sylhet Trap.

Totally distinct from this is the Khasia Trap, so massively developed in the interior of the hills, associated with the younger metamorphics. It is probably hypo-synchronous with these, *i. e.*, introduced (? formed) at the time of their main disturbance and metamorphism.

The granite occurring, both in large masses and in dykes, through the upper metamorphics is younger than the Khasia Trap.

The separation of the Shillong series (the upper metamorphics) from the Gneissic series, is conjecturally indicated.

The peculiar position of the plateau, between two great regions of disturbance, and the close relation of the stratigraphical features with the south-eastern of these mountain-regions are discussed as illustrative of current opinions upon crust-movements.

The occurrence of a sharply defined terrace of older alluvium round the west base of the Garo hills, and corresponding with the well known Madhoopoor jungle deposits in the plains to the south, is noticed with reference to the changes that have affected the delta of the great rivers.

October 1868.

ON THE OCCURRENCE OF GOLD IN THE DISTRICT OF SINGBHÚM, &C., BY VAL. BALL, ESQ., Geological Survey of India.

The existence of gold in the districts of the south-west frontier of Bengal and in the neighbouring tributary states has long been known. It is found not only in the sands of many rivers and streams, but in some instances it has been mined for in the alluvial and other superficial deposits.

Colonel Haughton in his interesting memorandum 'On the geological structure and mineral resources of the Singhbhúm Division,* has given an account of the gold washing, and enumerated several localities where gold mining had been, or was, at the time of his visits, carried on. He also quotes from a letter from Mr. Robinson in which that gentleman states the results of his attempts to establish gold-mining under European superintendence.

At Rohobe in Oodipur where operations were commenced and shewed some prospect of being fairly remunerative, the climate proved so "hot and unhealthy" that it was found that no European could live there, and the works were given up.

Colonel Haughton says that "the metal was found some years ago in considerable lumps "in the Sona Nuddee of Sonapet in Tamar on the northern extremity of Singhbhúm, "and much is still found there."

I have invariably found that the washers have traditions of nuggets having been found at intervals.

The cases of the gold having been found *in situ* are undoubtedly rare. Colonel Haughton speaks of it occurring in *(in situ?)* "a little north of Assuntitlea in Khursowa," but further on he states "I have not heard of any instance in which the metal has been found attached to a stone, so that the former statement must only mean to imply that it is mined for in superficial deposits." Dr. Emil Stœhr states† that traces of gold were found in the copper ores of Singbhúm.

A Mr. Emerson was specially employed by the Singbhúm Copper Company to investigate the gold resources of the country. He is said to have crushed a quantity of quartz and to have found traces of gold in it; but his operations do not appear to have been sufficiently successful to encourage him to continue.

When in Chaibassa last April, I was shewn a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kappergudee Ghat near Kalkapur in Dholbhúm.

It is not within the scope of the present paper to give a complete resumé of all that is recorded on the subject, but rather to give an account of what has actually come under my own observation in those portions of the districts which have been examined geologically.

During the season of 1866-67, Mr. Ormsby and myself fancied we were able to connect the occurrence of gold in the streams with the existence of certain submetamorphic rocks (magnesium and mica schists, slates and quartzites) which were then for the first time met with in Mânbhúm.

Being anxious to put this connection to as rigid a test as circumstances would admit of, and wishing to define, if possible, the exact boundaries within which gold certainly exists and may be reasonably looked for, I with some difficulty persuaded two gold washers (man

* J. A. S. B. XXIII, p. 103, 1854.

† Einige Bemerkungen über den District Singhbhum in Bengalen. Viertel Jahrs'schrift der Naturforschenden Geselschaft. Zurich, 5th year, Part 4, 1860.

and wife) to accompany me during my examination of the remaining portion of the district of Mânbhúm. They remained with me for upwards of three months, washing daily at such places as pointed out.

One of the most interesting results is, that the existence of gold in the metamorphic as well as the sub-metamorphic rocks has been satisfactorily proved. This, from various reasons, I was not prepared to expect. Colonel Haughton, who speaks of the granitic gneissose rocks as *igneous*, states that gold is never found in the streams traversing them. Again, the Natives, so far as my experience goes, do not wash in the sands, &c., lying on the metamorphic rocks, although they do not connect the existence of gold in the sands with the vicinity of any particular rock.

In Mânbhúm, the experience of generations of washers has enabled them to define the boundaries within which washing is remunerative; and this boundary, it is interesting to observe, corresponds on the north exactly with that of the sub-metamorphic rocks.* This coincidence I ascertained in the following manner. On my arrival at Dulmi (which is situated on the faulted boundary of these two groups of rocks) when marching northwards from the lower part of Pattrum, the gold-washer asked to be allowed to return to his own country (Dhalbhúm), stating that none of his race ever went north of Dulmi. I induced him however to stop, and while we remained north of the fault the washings were carried on in the granitic gneiss area with comparatively poor, but not exactly barren, results. On the day I crossed the fault south of Sindaree, when returning southwards, the gold-washer said that we should after that find gold more regularly and in greater quantities than we had done since we came north at Dulmi.

During the whole time, a record was kept of the daily results and of the nature of the rocks in which the washings were made. The following abstract will suffice for comparison of the productiveness of the two formations:—

Sub-metamorphics.

	January.	February.	March.	April	TOTAL.
Number of days on which washings were made	31	9	18	8	66
Unsuccessful days .. .	2	3	2	2	9 = 3·6 per cent.
Gold in grains	17·68	4·65	7·6	2·45	32·38
Daily average in grains ..	·57	·516	·4	·3	Daily average for whole period = ·46 grains.

Metamorphics.

	January.	February.	March.	April.	TOTAL.
Number of days on which washings were made		20			33
Unsuccessful days		13			22 = 66 per cent.
Total gold in grains		4·78	·7		5·48
Daily average			·05		Daily average for whole period $= \frac{5·48}{33} = ·16$.

* A line drawn across the southern part of Mânbhúm from Simlapal on the east through Burrabazar to a little north of Echagurh on the west, roughly indicates the position of the line of boundary between the two formations.

Comparing these results by the number of successful days first, we may say, that for gold producing, the submetamorphic rocks are to the metamorphics as (100—13·6=)86·4 to (100—66=)34=2·5 : 1; comparing by daily average, the proportions become ·46 : ·16=q. p. 3 : 1.

We may therefore conclude that the submetamorphics are between two and half and three times as productive of gold as the metamorphics, so that as the gold washers only find a subsistence from washing in the submetamorphic area, it is obvious that it would not pay them to work in the metamorphics.

The greatest amount found on one day was 2·2 grains, but the daily averages given above should not be taken as indicative of the amount of gold to be found by a regular system of working where the washers would of course be set at favorable spots, and would not have to spend a considerable portion of their time daily, as was the case of the men I employed, in making marches before they reached the scene of their labours.*

Various papers in the Asiatic Society's Journal describe the methods of gold-washing practised in different parts of India. The instruments used, though essentially the same in principle throughout, have local peculiarities of shape, &c., and the manner of manipulation also varies.

At Heera Khund† the same instrument and manipulation serve for the separation of both diamonds and gold. In fact the diamonds are found in the middle of the process, the iron sand with specks of gold being the final residue.

In Mânbhúm and Singbhúm the instruments used are perhaps more simple than those used in any other place. The dish measures 28″ by 18″, it is hollowed somewhat eccentrically to a maximum depth of about 2½ inches. A scraper formed of a flattened iron-hook set in a handle, serves to collect the auriferious sand and gravel which accumulates in the angles of the rocks in the beds of streams. The dish when filled is placed in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions.

The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron-sand in which the specks of gold are readily apparent.

The gold-washers belong to the lowest and poorest races in the country, Gassees according to Colonel Haughton, but some of those which I met with were a race of kumars, called Dokras. Their numbers have been greatly reduced by the famine; without exception they are all in the power of the Mahajuns, for whom they work at a low rate, and are never able to free themselves of the claims which the Mahajuns make on account of advances.

The daily earnings of the gold-washers are small, but might no doubt be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

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* It is conceivable that the fact of the greater quantity of gold being found in the superficial deposits within the submetamorphic area might be atttributable to something in the configuration or elevation of the ground conducive to the greater accumulation of gold within that area. I could not however discover anything of this kind; the fall to south is gradual throughout both formations.

The origin of the gold which is annually found in the rivers at present is, I believe, twofold. A portion being directly derived from the rocks and the remainder resulting from the re-assortment of detritus which is the remanet of sub-aerial action.

In both formations, the evidences of extensive sub-aerial action are numerous and prominent, and it is obvious that nature has been carrying on gold washing operations in the valleys, since denudation first commenced to scoop them out, leaving barriers of intervening ranges of hills formed of the hardest rocks between them.

† J. A. S. B. VIII. 1057, 1839.

Colonel Haughton says—"The Gassees can always reckon on earning from three to four pice per day, and I am assured that a vigorous man often gets as much as twelve annas, which, as the ordinary rate of field labour is about one pice, must be considered a very large sum."*

Mr. Robinson found in a trial which he made at Rohobe in Oodipur, that men to whom he paid one anna could produce for him from three to four annas worth of gold.

Colonel Dalton states that the washers themselves regard it as a very poor trade, simply yielding they say *pét bur* (bellyful).

Dr. Stœhr in his paper on Singhbhúm states that he found the average daily earning to be about 25 centimes (rather more than an anna and a half).

The men I met with stated that they could earn about an anna a day and occasionally three or four annas.

Taking into consideration the manner in which the gold is distributed through the superficial deposits of these districts, it would seem that the system of hydraulic mining, at present practised in California, is the one which would be most likely to be successful.

In a recently published account† of that system we learn that there is a company in California which supplies water to the miners at such a moderate rate that "350 miner's inches of water, with a head of 160 feet, will remove and wash 4,000 tons of gravel per diem, leaving a small profit on the working of stuff affording gold to the value of only three half pence per ton."

In parts of the districts under consideration it would be hopeless to expect to obtain a constant and sufficient supply of water with the necessary head-way: but there must be many places at the bases of the plateaux which rise towards the west, where the conditions would be peculiarly favourable. During the rains the number of such places would of course be vastly increased.

The simplest idea of this process, which seems so nearly to approach to perfection in California, is not, however, altogether unknown to the natives. Mr. Robinson says‡—"Another plan and a very remarkable one in which the people collect the gold is by drawing up small watercourses before the rains, so as to make places for a deposit of soil carried down by the water; this soil is cleared out several times and in it is found a large deposit of gold."

In the shallow diggings the hydraulic system would not of course be applicable, but even in them an increased field would undoubtedly result from supplanting the native's dish by the Californian pan, rocker, long-tom and sluice.

September, 1868.

MEMORANDUM ON THE WELLS NOW BEING SUNK AT THE EUROPEAN PENITENTIARY, AND AT THE SITE FOR THE CENTRAL JAIL, HAZAREEBAGH, *by* H. B. MEDLICOTT, F. G. S., GEOLOGICAL SURVEY OF INDIA.

1. All the rocks of Hazareebagh are of the most extreme metamorphic type, and are besides very irregularly arranged. It will, therefore, be at once understood that a question of water-supply, in which these rocks are concerned, is altogether beyond those simpler cases where a study of the sections might enable a Geologist to give an approximate positive judgment upon the source of water in any given position. The independent method being thus not applicable, I had to trust to the discussion of existing local experience, and the comparison of this with the special cases proposed, with the following results.

2. Hazareebagh is on an undulating upland. There is nowhere any strictly level ground; but the tops of the ridges are generally very flat, and the slopes very gentle. It

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* J. A. S. B., 1854, p. 109.

† Quar. Journal of Science, XIX, July 1868.

‡ J. A. S. B., 1854, p. 108.

is only in the immediate neighbourhood of the main stream-channels that rougher and steeper ground occurs, and also where rocks come to, or near to, the surface, whether on the slopes, or on the ridges. But even in this latter case, the summits of such ridges are very approximately on the same level as those where no rock is to be seen; I regret that available information does not enable me to give figures. Over large areas, as in and about the Station and Cantonments, no rock whatever is exposed. From the few glimpses I was able to get in the upper part of unlined wells or in ditches, it would appear that such areas are formed of a dark stiff sandy clay, tinted with iron, and mottled with concentrated granules of the same in varying proportions. The greatest thickness I was able to observe of this stratum was 14 feet in a partially dug well, where the water level had not yet been reached; but, no doubt, it locally attains greater dimensions. I could not fully satisfy myself, from an inspection of this clay, whether it is purely derived from the decomposition in place of the subjacent rock, or whether it be in some manner alluvial, a point that would bear importantly upon the under-ground distribution of the water. I incline to the former view; but, if correct, the rocks must be there unusually free from the quartz-veins which occur so abundantly in the exposed rock sections, and which veins would remain in position and unaffected in the clay. This stratum forms a cold and retentive under-clay: the upper two feet or so of a paler colour, where de- and re-composition has further advanced, forms a slightly improved sub-soil, yielding at the surface a very poor soil. Where the iron and the sand are not in excess, the under-clay forms an excellent brick-clay; the upper layer being fit for tiles. Below this clay, I am told, there comes suddenly an unknown thickness of incoherent sandy or gravelly material, in which the water runs freely; but from the very apocryphal descriptions I have received, I am quite unable to say whether this be a diluvial deposit, or merely disintegrated rock in place; what has been conjectured regarding the clay may show that I incline to the latter view: the evidence of any old heaps or of well-clearings is in favor of it. The greatly preponderating rock of the region is a finely granular hornblendic gneiss. From a list of measurements taken in 42 wells within Cantonments, and a partially contoured plan, both furnished to me by the Executive Engineer, I have made the annexed tabular statement, from which a few inferences may be gleaned. In none of these wells, that I could hear of, was anything like *rock* met with.

3. It is remarked on the list that "those measured in the evening have often been largely drawn upon, as No. 14 on the south side of the Plunge-bath. Early measurements for all would have been better, even if it had to be done on consecutive days; it would seem, however, that the discrepancies thus introduced may balance each other in the averages of the several groups; but the data being thus not comparable, and there being no collateral information, one is left without a clue to an explanation of what may be only apparent anomalies; such as Nos. 26 and 27, deep wells, exhausted, while much shallower wells in the same neighbourhood hold several feet of water. In all such statistics, the original depths to which the wells were sunk should be the measure given; this ought to be in a permanent record and with it some attempt, however rough, to describe the materials cut through. All should, moreover, be easily referrible to the level of the lowest drainage point of the region as a datum line.

4. The table, contrary to what might have been expected, shows no decided advantage in the supply to wells at a lower level.

5. There is a very marked advantage shown, as was of course to be expected, in an increase to the depth of the wells; there is at least 6 inches gained in the daily supply for every foot in depth below a certain point. I say *daily* supply, for I do not think that the depth of a well would affect its permanent level: thus Nos. 2 and 3 are within 70 yards of each other, neither was much in use; and although No. 3 is deeper by 8 feet 6 inches, there is only 1 foot 3 inches difference in the water level, and even this is in favor of the shallower well. From every consideration it is manifest to me that to have an unfailing supply of the best water in Cantonments, it is only necessary to sink a few feet lower than has been the practice, and, I might add, to adopt some less primitive mode of drawing water than that of hauling in buckets. Where there are only a few feet of water, this mode of raising makes it turbid and unfit for immediate use. Serious difficulty seems to have been felt in attempting to carry the wells even to their present depth; but I cannot find that any proper means have been tried to overcome this difficulty, such as the use of some method of shoring up the sides while the work is being carried on in friable, watery ground, and at the same time some means of unwatering more effectual than the obstructive one of baling and hauling.

6. Several figures in the list show how safely the water is stored below; how slowly, but surely, the supply recovers when drawn upon. These measurements were taken on the 5th of June, after a long season of drought. Dr. J. M. Coates, Superintendent of Jails, has kindly given me a statement of the rain-falls for the preceding months:—January, 0·26; February, 0·97; March, 0·64; April, 0·0; May, 1·54; up to 5th June, 0·59. The scarcity was much felt, but it was not an extreme case. I am told that worse seasons have been experienced, still there were 13 and 20 feet of water in wells Nos. 2 and 3 at a depth from the surface of 26 and 27 feet: In other cases, as Nos. 6 and 14, a fair daily supply was renewed nightly. The stratum of clay can be but very slightly permeable to water, and can contribute little; all the evidence goes to show that the water is lodged in the disintegrated upper portions of the under-lying gneiss. The depth to which this decomposition takes place is variable according to the variety of the rock in different spots; but it is generally very considerable, and in every case I would take that as the depth to which a well may be sunk with advantage. The moderate permeability of this rotten rock, as shown by the facts just quoted, suggests an alternative to the deep sinking which has been recommended as the best safeguard against scarcity: it would seem that wells may be sunk within 80 to 100 yards of each other without seriously affecting the daily supply in each within the limits of ordinary demand.

7. In connection with the question here discussed, I would bring to notice an allied one of equal importance. In the 13 days following the 6th June there fell 14·43" of rain, and all the wells were filled to within a foot of, or were quite up to, the surface. This is their condition for months throughout the rainy season, after which they slowly subside to their minimum at the end of the ensuing hot season. Such a state of things will seem strange after what has been said of the configuration of the ground, that the surface drainage is ample in every direction; and that at no great distance the rocks outcrop in valleys much below the general level of the country, unless from artificial causes there is no surface lodgement of water. It may seem stranger that it should be allowed to remain so. I have lately heard doubts expressed as to the reputed healthiness of Hazareebaugh. Without in the least wishing to endorse such an opinion, against which there is much presumptive evidence, I may remark that, according to received notions, it seems like neglecting a means of improved healthiness to allow the water to be so near the surface. It may be said, and I am not prepared to deny the assertion, that so long as the water is even a few inches under ground, it is innocuous; that it is only when allowed to stagnate on the surface that it becomes injurious; if it be so, most of the ground would require no treatment, but there would remain much to be done. When I passed through Hazareebaugh in the middle of November 1866, after we had many days of hot sunny weather, I noticed soft sludgy ground in many places, even within a short stone's-throw of the barracks. At half-way down the slopes of the shallow hollows the water does ooze out, creating this boggy ground, so long as the general water level remains above the level of the channel. Surely this would come within the limits of the conditions to which the autumnal unhealthiness is attributed all over India. But here, not as in the cities of the plains, the remedy is easy; the most complete facilities exist for drainage of any required degree. Of drainage, such as is usually understood in India, Hazareebagh has had its fair share: the natural water channels and the cuts along the roadside, or elsewhere, are kept clear, but in such a sub-soil as that here the effect of this is imperceptible. Drainage to be effectual should be such "thorough drainage" as a farmer would apply to similar land in Scotland, if he wanted to bring it under tillage.

8. The Civil Station adjoins Cantonments immediately on the north-west, the ground being apparently slightly higher. Here, about the Zillah Jail, and in the grounds of the house occupied by the Superintendent of Jails, I saw some sections in unlined wells somewhat different from what would seem to be the rule in Cantonments, in so far as that the clay, which is of precisely the same character as elsewhere, is much less thick, not more than 6 to 10 feet. The rock does not appear at the surface. Even here I could not satisfy myself upon the mode of origin of the clay; there seems to be generally at the base a foot or so, in which coarse quartz debris is abundant and irregularly scattered. Here, however, it is certain that the water-yielding rock is the porous rotten gneiss, in which the wells are dug without any difficulty. It is often so loose as to crumble away and fall in.

9. We may now come to the main object of our investigation. The European Penitentiary stands about three-fourths of a mile to north-north-east of Cantonments, and separated from them by a broad valley, some 40 feet deep, passing up to westwards, in which

direction the ridges are confluent. The site for the Central Jail is some few score yards beyond the Penitentiary, on another minor branch of the same system of ridges. In both localities rock crops out freely in many places, and it might have been anticipated from the beginning that the well question would assume a very different aspect from that of any case within local experience. It were useless to moralise upon so common an occurrence as want of foresight, or to indicate its source in this particular instance.

10. In the Penitentiary well there is no clay at top. After about 3 feet of coarse quartz gravel, mixed with red sandy earth, they come upon a run of largely crystallized granite (pegmatite) very irregularly associated with hornblendic gneiss. At first this mass was not difficult to be cut, although not nearly so soft as the rotten rock already spoken of, but it rapidly became harder, and at about 20 feet blasting had to be resorted to. All effects of decomposition from surface atmospheric influence having ceased, the stone showed its true characters of intense hardness and complete impermeability. The arrangement of the bedding, if, indeed, it be true bedding, in this short shaft is exceedingly irregular, at one spot apparently dipping to the north, and at another to the west. In the hard rock at base there are some well marked joint planes showing large flat surfaces nearly vertical, but these joints do not seem to be available for the percolation of water; the few leakages that occur are from points in the indefinite cracks that traverse the stone discontinuously without any system, and generally where there is a film or layer of partially disintegrated rock. Near the base of the shaft another vein of granite like that at top, but thinner, traverses the gneiss irregularly at a low average angle, but here it is firmly united with the containing rock, the same even surface of fracture passing indiscriminately through both. I waited for several days to have this well emptied, but the water was still knee-deep at my last examination. I do not consider that I have lost any evidence of importance.

11. From the accounts I have received, there would seem to be some prospect of immediate success. I am informed by Dr. Coates that a few days before the work closed at the end of the hot season, he made a rough measurement of the leakage water, and found it to be about 40 gallons per hour, nearly 1,000 per day. I confess that this surprises me much: the excavation then was at about the level the water stood at when I saw it last, and the leakage did not seem to me any thing like so much, although the time of year was so much more favorable, and the well had just been emptied by double gangs of men working day and night. Subsequent to that measurement, the last few blasts put into the rock disclosed one or more layers much softer than any met with for some yards above, and from which water flowed in much greater abundance than from any of the higher points. Unfortunately the rains put a stop to the work before this ground could be fully proved. The only symptoms I could detect of these sources was that, in walking about through the water, I felt at two or three spots a very appreciable warmth under my feet. The first thing to be done now is fully to test this ground. Five or 6 feet more of cutting ought to prove what it is worth. But a large margin ought to be left above any measurement made now for the diminution that may be expected in the dry season.

12. There can, of course, be no doubt of ultimate success: accumulated drippings will at last yield the required supply. But this must remain matter of experiment. No one but a diviner would venture to predict at what point success would be attained in rocks like these. There is, however, an evident choice as to the direction in which these contributions are to be sought. That word "spring" has a great deal to answer for: most men seem to think that water comes from the bowels of the earth, whereas in 99 out of 100 apparent cases the source is from above. The only available, and the only known, source of water here is the one already pointed out, the porous mass of disintegrated rock at the out-crop under the clay. This being the case, I would decidedly recommend, in the event of the next few feet in depth not giving the required supply, that the vertical shaft be changed for a nearly horizontal drift. The chances are almost all in favor of this plan, and there is here the ultimate certainty of tapping the source itself in the most effectual manner from below. In the vertical shaft there is no doubt the chance of contributions from every side, while in the drift we must select the most likely direction, but I am in favor of this attempt. There are two elements for consideration, the structure of the rocks, and the lie of the surface. From what has been seen of the rocks in the Penitentiary well, there is little or no room for choice; they have no definite arrangement. The most frequent run of the rocks in this neighbourhood is about north-north-west, and so the most likely line to cut them would be at right angles to that direction. The *primâ facie* view of the second condition would

suggest to make straight for the nearest point of the slope of the ridge, but it must be modified in this case. I have carefully examined the line of the surface, and should consider that course to be unsafe; the slope to the south is too near and too rapid. The ground from which a supply is to be expected lies to the west and west-south-west. I would recommend that the drift be cut to west-30°-south, with a rise of 1 in 20. This direction, too, would approximately suit the probable run of the strata.

13. There is at least one advantage in having the well in solid rock; it may be left with its present full width, and only cased for 20 feet or so from the surface. I would recommend that this be done at once; and that the pump, by which it is to be hoped the future water-supply is to be raised, be put in position now. In such a well, too, the work can be continued at any time as well as at first, should a season's trial prove the supply to be insufficient. I would not, however, let this be an excuse for an incomplete job at first; the failure would, of course, occur in a season of extreme drought, and might be seriously felt. But, indeed, the energy of Dr. Coates has provided an excellent resource for a time of such need, by converting the unsightly and doubtfully salubrious ravine in front of the Penitentiary into a most picturesque lake of deep water. A very little care on the part of the authorities can prevent any possibility of its becoming unwholesome.

14. The case of the Central Jail well is quite analogous to that of the Penitentiary, but a little more puzzling. Here too, however, I would recommend the prosecution of the work. I believe that success can be secured at a much less cost than would be entailed by abandoning the site upon which preparation and work has been already so far expended. At top there were 6 to 8 feet of red gravelly earth, resting on the edges of the strata, which are thoroughly disintegrated for 3 to 4 feet passing down into much firmer rock. Unlike in other wells the beds here have a steady dip of 40° to north-35°-west. At a depth of 30 feet on the rise, and 38 on the fall, an intensely hard rock was encountered, in which the work now stands at 40 feet. This well also had just been unwatered; and considering this, and the time of year, the leakage appeared to me to be very trifling. The last rock cut in this well is exceedingly unpromising; the large surface of it now exposed does not show a single crack or crevice. It breaks with sharp edges and large conchoidal fracture: it is a fine grained mixture of hornblende quartz and felspar thoroughly crystallized; superficially it might be described as a granitic diorite; but geologically it must come under the genus gneiss, as it seems to be strictly in the bedding, and to be simply an exaggerated form of the fine foliated hornblendic gneiss of the district. A correct knowledge of this rock would greatly help a decision regarding the well; but very little can be discovered; there is no out crop of it to be found. On the other side of the Penitentiary, at the edge of the upper lake, an exactly similar rock is exposed for fully 10 yards across its strike. Thus in the well shaft there is a prospect of having to cut through an indefinite thickness of perfectly barren rock, and of the most difficult nature. The same obstacle affects the consideration of a drift. In this position, also, the condition of the surface is of dominant importance on account of the rapid fall in certain directions. The most likely direction for a drift to intercept an abundant supply of water would be about due south, but this would take it into the same rock, and even for a greater thickness than in the shaft, the cut being oblique both to the strike and the dip; here, however, there would be the prospect of its becoming softer at every step. I have no doubt of this being the safest course. The lower the inclination of the drift, the better the chance. I would not advise a greater slope than would ensure the flow of water to the shaft. By cutting the drift to northward, it would run towards a convex bend of the ridge, and success would not be so secure; but the obnoxious rock (at least this bed of it) would be avoided.

15. There is one well in a position to be compared with these. The well for the Police Barrack stands nearly centrally on the ridge of which the new buildings occupy prolongations: it is 470 yards to west-18°-north from the Penitentiary well (the distances are taken from a plan lent to me by Colonel Dawson) and 1 foot 9 inches higher; the same well is 700 yards to south-42°-west from the Central Jail well, and 4 feet 6 inches above it. It is 30 feet deep. I have had very different accounts of this well: like all the others, it fills to the brim in the rains, and some say that it has a constant supply, the demand upon it not being very great; while others declare that it fails; that in the hot weather people living along side it fetch water from a considerable distance in the hollow. Some measurements of these three wells are given in Table II. The water in the two new wells on the 10th October was probably below what they had contained at their fullest; but even that

quantity shows that on the 19th June, when every other well in the place was at its full, these were still at least 10 and 6 feet below their minimum height, an indication of the slow and circuitous percolation by which they are fed.

I have made this report rather long, but I thought it best to omit nothing that might give information.

23rd November 1868.

TABLE I.

Table of depths of Water and of Wells in Cantonments as measured on the 5th June 1868, just before commencement of the rains, grouped according to levels of sites.

Number of Well.	OVER 88′ CONTOUR.		BETWEEN 88′ AND 84′		BETWEEN 84′ AND 80′		UNDER 80′		REMARKS.
	Depth		Depth		Depth		Depth		
	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	
1	7·6	37·0	...	...	...	...	...	...	
2	13·0	38·9	...	...	...	...	...	...	Within 210 feet of No 3.
3	20·1	47·3	...	...	...	...	...	...	These two wells were little used.
4	...	...	7·5	32·6	...	...	...	...	
5	...	...	5 1	35·3	...	...		...	
6	...	...	...	...	1·3	32·5		...	Much used
7	...	...	...	...	1·4	19·8		...	
8	...	...	...	...	3·0	17 75	...	...	
9	7·0	37·3	...	...	...	...	...	...	
10	9·1	40 3	...	...		...	...	...	
11	...	...	2 9	35·5		...	...	...	
12	...	...	...		5 0	34 5	...	...	
13	...	...	3·3	32 5	...	...	...	...	
14	...	...	2·0	38 0		...	...	...	Much used.
15	...	...	...	...		...	6·9	30·25	
16	...	...	7·0	35·5	...	...	...	...	
17	...	...	7·7	31 1	...	...	...	...	
18	...	...		...	...	...	1·8	20·5	
19	...	...	3·0	30·0	...	...	...	...	
20	...	...	1·5	39·5			...	...	
21	...	...	...	...	...		7·5	36·6	
22	...	...	...	...	...	...	5·2	31·8	
23	...	...	...	...	...	...	5·5	32 5	
24	...	...	...	...	...	...	2·0	25 0	
25	...	...	...	...		...	3·25	27 25	
26	...	...	...	...	...	...	0 3	34·25	
27	...	...	...	...		...	0·3	31·25	
28	...	...	...	...	...	...	2 5	33 5	
29	...	...	...	...	...	...	4·5	33·5	
30	...	...	3·0	25·0	...	...	...	...	
31	...	...	...	...	...	...	1·4	19 0	
32	...	...	...	...	...	...	4·3	24·3	
33	1·0	29·0	...	...	...	...	...	...	
34	6·2	38·2	...	...	...	...	...	...	
35	2·2	24·2	...	...	...	...	...		
36	6·4	32·4	...	...	...	...	...	...	
37	9·2	40·2	...	...	...		...	...	The four last are within a radius of 180 feet.
38	4·6	35·6	...	...	...	...	...	...	
39	6·0	28·5	...	...	...	...	...		
40	0·0	21·0	...	...	...	...	...		Within 80 feet of No. 39.
41	7·2	32·2	...	...	...	...	...	...	
42	0·0	29·0	...	...	...	...	...	...	The five last are within a radius Of 256 feet.
	79·5	442·8	43·0	304·0	10·7	104·55	45·45	379·70	
Mean of 13	6·1	34·0	...	...	...	...	...	...	Nos. 3 and 40 are omitted as exceptional.
„ of 10	...	...	4·3	30·4	...	...	...	...	
„ of 4	...	...	...	...	2·7	26·1	...		
„ of 13	...	...	...	...	...	...	3·5	29·2	

TABLE II.

Table of measurements in the new Jail Wells.

	Depth of Well.	Depth of Water on 19th June.		Depth of Water on 10th October.	
	feet.	feet.	inches.	feet.	inches.
A. Police Well	30	28	0	22	6
B. Penitentiary, 1'—9" below A.	56	38	0	43	6
C. Central Jail, 4'—6" „ „	39	21	6	31	0

METEORITES.—To the collection of Meteorites in the Geological Museum, there have been two valuable additions during the past three months. One of these, a specimen of the very interesting fall which occurred on the 11th July 1868, at Ornans (Doubs), in France, has been presented by M. Jules Marcou, Paris. It is a remarkable stone of a dark-grey colour, oolitic or sub-oolitic in texture, very friable, so as even to crumble under the action of the fingers. Iron is present in extremely small particles. It is very slightly magnetic. In fact, the fall represents a state intermediate between the ferruginous and the non-ferruginous falls, sp. gr. 3·599 (in fragments). It yielded to Pisani by analysis no less than 75·10 per cent. of Peridot. To the kindness of my good friend M. Marcou I am indebted for this interesting specimen.

The second fall occurred in India, near Mooltan, on the 17th October. The fall took place at a spot about 12 miles east of Lodran. "About 2 P. M. a loud report was heard "in the sky to the westward, and immediately a cloud of dust rose from the ground. On "going to the spot the ærolite was found. The sky was quite clear at the time." This is the account given by Captain Bond, District Superintendent of Police.

A portion only of the mass was obtained and forwarded. It is a very beautiful stone, consisting of a large proportion of bright yellowish green olivine, the crystals of which are imbedded in a kind of crystalline network of brilliant iron. The stone is at present being analyzed, and the result will be given hereafter.—T. O.

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BIGSBY, J. J.—*Thesaurus Siluricus.* The flora and fauna of the Silurian period, 4to., London, 1868.

CHANTRE, E.—E'tudes paléo-ethnologiques ou recherches Geologico-archéologiques sur l'industrie et les mœurs de l'homme des temps anté-historiques dans le nord du Dauphiné et les environs de Lyon, 4to., Paris and Lyon, 1867.

CONGRES international d'anthropologie et d'archeologie préhistoriques, Liv. 1, 8vo., Paris, 1868.

D'ALTON, DR. E., UND BURMEISTER, DR. H.—Der fossile gavial von Boll in Wurttemberg mit bezugnahme auf die lebenden Krokodilinen nach seiner gesamnten organisation Zoologish geschildert, Fol., Halle, 1854.

ELLIOT, SIR H.—History of India, Vol. 1, 8vo., London, 1868.

GOVERNMENT OF INDIA.

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ERDMANN, A.—Exposé des Formations Quaternaires de la Suéde. Text and Atlas, 8vo. and 4to., 1867.
DIRECTEUR-IN-CHEF DE LA RECHERCHE GEOLOGIQUE DE LA SUEDE.

FOLIN, L. DE.—Les Méléagrinicoles, espèces nouvelles, 8vo., Havre, 1867.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 1.] 1870 [February.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1869.

The close of another year (1869) calls for a brief summary of the progress of the Geological Survey since our last report.

The area, which it is possible to examine geologically within a year, depending essentially on the number and ability of the officers employed, it is necessary, first, to premise that during ten months of the twelve just passed, Mr. W. T. Blanford, Deputy Superintendent, was absent, being engaged in the elaboration of his report on the Geology and Natural History of Abyssinia, the result of observations made while attached as Naturalist to the Abyssinian Field Force, and during a brief visit, subsequently to the return of this force from Abyssinia, to the adjoining territory of Bogos. Mr. Blanford was, at the beginning of the year (1869), ordered to proceed to Europe, where alone he could have facilities for the comparison and identification of his collections and of reference to all previously published accounts. After an absence from India, on this duty, of about six months, Mr. Blanford rejoined the Geological Survey at the beginning of November, and immediately took the field. Mr. Ormsby, who (as reported last year) had been obliged to proceed to Europe, suffering from sunstroke, returned just before the working season commenced in November. During the most important and largest portion of the year, therefore, the survey was without the aid of these two gentlemen. Mr. W. King and Mr. F. Mallet obtained 12 months' furlough each, and left in September for Europe, having completed their maps and reports of the previous season; and their services will, of course, be wanting during the present season. Last year I had to report that Mr. Charles Oldham had proceeded on furlough in November, and with deep regret I was called on to report his decease in April last. In him the Government of India lost a trained and able servant, distinguished for his conscientious devotion to duty, and for the care and skill with which he, as Deputy Superintendent for Madras, conducted the labours of the party working there. In him also the officers of the Survey regret the loss of an esteemed colleague. This death, resulting from the effects of an attack contracted during his active service in India, adds another to the long list of those who have succumbed to the very trying exposure in the worst and most unhealthy parts of the country which the pursuit of Geology in India necessarily entails. The remaining officers of the Survey have all been actively engaged during the year.

Soon after the commencement of the year (1869), having then just returned from the Punjab, I proceeded to Cachar and Sylhet, to examine, on the spot, the evidence connected with the serious earthquake of the 10th of January, which had caused such extensive damage. I was unfortunate in visiting the localities just at the time when all the available carriage of the district was needed for the Military expedition then just leaving Silchar; so that I found it impracticable to see quite as much of the country as I could have wished. I succeeded, however, in obtaining some accurate and valuable observations. And in returning I crossed the Khasi Hills, noting the results of the same earthquake at Sylhet, Cherra Poonjee, Shillong, and Gowhatty. A brief notice of these results was given at a meeting of the Asiatic Society of Bengal in March (*vide* Proceedings of the Society for April 1869, p. 113). While working out these observations, I was led to notice how little of any accurate record existed in this country regarding the earthquake shocks to which many parts of it are frequently subject. And I have, therefore, given some time to the preparation of as perfect a catalogue of Indian earthquakes as I had means of obtaining. This will, I believe, prove an useful addition to Indian seismo-statistics, and I trust may at the same time be the means of eliciting further information on the subject. Many private records of such phenomena doubtless exist, full of interesting and often valuable information, which has never been given to the public. I would solicit the contribution of any such facts as may tend to prove the occurrence of shocks not hitherto noticed, or to indicate the extent of area over which, and the relative violence or intensity with which, shocks already recorded may have been felt in different parts of the country. The very nature of such a catalogue precludes the possibility of successful compilation by any unaided individual; the co-operation of many is essential. A report of the effects of the earthquake of 10th January, 1869, is in progress.

At the beginning of November, I proceeded to the Central Provinces to control the operations there in progress for the exploration of the coal in Chanda and Berar. I found that the late rains of the year had caused a good deal of fever in many places, and the taking of the field by the Survey Party was a little delayed in consequence. Proceeding from Nagpore in company with Mr. C. Bernard, Commissioner of Nagpore, in whose jurisdiction the Chanda district is, I first took a general review of the field as far south as Ballarpur. And then returning fixed upon positions for future borings, with a view to test not only the continuity of the beds of coal which the river Wurdah had exposed in one or two places, but also to prove the nature, thickness, and contents of the coal-bearing formation generally. I have seldom seen a country less favorable for detailed Geological research, as a thick covering of clays conceals the rocks entirely, excepting at distant intervals. Any detailed examination, therefore, necessarily takes much time, and cannot in the end be very satisfactory. But, with the aid of borings, we hope to be able to trace out the rocks with tolerable accuracy.

The results of the trials up to November last were published in the last part of the Records of the Survey (Part 4, 1869), and it is not necessary to repeat them here. Since that time, up to date, additional information has been gained, which is all satisfactory. One of the great sources of doubt as to the extent of the coal deposits arose from the widely established fact, that the beds in the group of rocks in which the coal here occurs (that known to Indian Geologists as the Barakar group) had invariably a tendency to exhibit very great variation both in thickness and quality within short distances. They are often of great thickness locally, but thin out and nearly disappear within short distances: this variation also being not only in the thickness, but also in the quality of the beds, so that what shows as a bed of good coal in one place may, within a few yards or a few hundreds of yards, pass into a shale without coal, or even into a sandstone. It was, therefore, important to test this, and the first new boring which was fixed on was put down near the village of Telwasa, some ten miles to the north of where the coal had been found in the river. No coal was visible, nor had any been ever known to be there; but the position in which it ought to be found, if the beds continued, was, as appeared to me, well marked. After some delays, the rods were put down here, and passing through the beds of sandstone, seen on the surface, they entered a group of beds of coal and shale, in the proper position exactly as anticipated. Up to the close of the year, 19 feet of this coal, with a few shale partings, had been cut into and the beds still continued.* Near the village of Nokora also, to the extreme south end of the small area of coal-bearing rocks which occurs on the Chanda side of the Wurdah river, near Ghúgús, the limits of which had been approximately fixed by Mr. Blanford in 1866, a bore-hole was put down by Mr. Fryar to test the character of the beds there. This has cut the same group of beds with coal found to the north of Ghùgùs village. There are representatives of the two upper beds, and then of the thicker group of shale and coal below. But, as expected, there is a large amount of variation in the actual section. The thick beds of so-called coal and shale noticed in the borings at the north of Ghúgús (see Records, Geological Survey, 1869, p. 97), as being there altogether some 33 feet in thickness, have increased to more than 50 feet at Nokora; but this increase in aggregate thickness is chiefly in the greater development of the earthy or shale beds. The details of measurements need not be given here.

The results, so far as the explorations have been carried, seem to me to point to the *general* continuity of the coals on a fixed horizon in the lower sandstones, and if this be confirmed by further examination, these coals may be sought for with considerable certainty within

* Forty-one feet, seven inches, of coal have been cut altogether here, in a total depth of 135 feet.

the very limited area which these rocks occupy. Until the recent trials, I regret to say that no principle seems to have guided the selections of the several points at which bore-holes were put down. They were apparently put down completely at hap-hazard, and were of course, in most cases, without any definite result. Localities have now been absolutely fixed upon for a number of additional borings, where, at comparatively small depths, the presence or absence of the coal may be determined.

A steam-boring machine has also been delivered at Chanda, but it is not yet in operation. It will in reality be of very trifling use in this field. The country is to an immense extent either covered with jungle or with deep beds of clay, through which every little stream cuts a deep channel or gully, and in either case there are no roads excepting of the most primitive character. There are not, therefore, more than half a dozen spots in the district to which this steam-boring machine can be conveyed, excepting at great loss of time and expense. And even in those localities, the required information can be obtained with ordinary boring tools more cheaply and expeditiously if only a systematic system of choice of position be acted upon. It is, however, hoped that a trial will soon be made with this steam-boring machine when the services of some one competent to undertake the management of it can be obtained.

To Major C. B. Lucie-Smith, Deputy Commissioner of Chanda, I am indebted for the most hearty and effective assistance in all things. The Geological Survey is also indebted to Mr. S. H. Hennessy, Extra Assistant Commissioner, for the earnest and friendly way in which he has ever met their wishes.

It is hoped that as soon as the Chanda district is examined, the investigations of the Geological Survey may be continued down the valley of the Godavery, at detached points in which we know of the existence of small basins of the coal measure rocks, in which coal may exist in good workable quantity. Such a basin, for example, occurs about 15 miles north of Dumagudiam, from which, at the place indicated by Mr. W. Blanford in 1866 near the junction of the Tal river, in the left bank close to the village of Lingala, a considerable quantity of coal was raised last year from the bed of the river. This coal worked effectively in the low pressure stationary engines, but was not sufficient to keep up steam for the high pressure engines of some of the steamers. I am also indebted to Colonel Haig, R. E., for the information that coal has been again found exposed in the scarped face of the rocks on the right bank of the river, about 34 miles below Dumagudiam. 'About two feet are seen above water level, and it extends under the water as far as a man can reach with his arm.' All these facts point to the necessity of an early and careful examination of this country. And it is my purpose next working season to work up from the Madras side, the party of the survey there engaged bringing up with them the extended knowledge they have obtained of the older groups of rocks in the Madras Presidency and the officers of the survey from Bengal working downwards, and bringing with them their widely acquired intimacy with the structure, character, and sub-divisions of the coal measures of India. The extent of country to be visited is, however, wide, and the detailed examination of so large an area will unavoidably occupy much time. The result of a systematic examination of this kind will, however, be more satisfactory and more trustworthy than if taken up at detached points.

In connection with these practical explorations by boring for coal, &c., I would notice the great satisfaction with which the Geological Survey have seen lately the success of that most important trial for water at Umballa. The insufficiency of the supply of water at this large station has long been a source of anxiety, and a cause of ill-health, and has led to proposals for the adoption of very costly and tedious works to increase the amount of available water and to facilitate its distribution. Mr. H. B. Medlicott, after his examination of the Sub-Himalayan rocks, urged the importance of seeking this much-needed supply of water in the water-bearing beds which must exist under all the country in that parallel along the foot of the hills.* The reasons for the confident expectation of good water being found there with a pressure at least sufficient to bring it to, or near to, the surface from very considerable depths were stated, and have, on several occasions since then, been very strongly urged. It was therefore with no small satisfaction that we saw the very first trial confirm the justice of these sanguine expectations. It is to be hoped that further trials will be now boldly

* Memoirs of Geological Survey of India, vol. III., pt. II. p. 181.

carried out, but at the same time strictly limited to those areas where the probable existence of similar conditions may be fairly anticipated after proper examination.

As stated in my last annual report Mr. Medlicott was, at the commencement of the year, engaged in the examination of the very important geological questions of the extent and stratigraphical relations of the several series of sandstones, &c., associated with the coal in Bengal as compared with those in Central India. In pursuance of this object, he traversed the entire country between Hazaribagh and Palamow on the east and Jubbulpur, on the west; and thence went southwards to Nagpore and Chanda. This extended and general survey of the vast area occupied by these rocks has brought into greater prominence and clearness, and has established the wider application of several of the views already enunciated by other officers of the Survey regarding the distribution and variation in character of the several sub-divisions of that great series of beds, in some members of which the coals of India chiefly occur, and which may, as a whole, and in a broad view of its fossil contents, be called the plant-bearing series. The vast extension and wonderful constancy in mineral character (combined with local peculiarities) of the *Talchir* rocks, which have always been treated of as the base of this great series, although forming in themselves a well marked and characteristic group, has been even more fully established than it previously had been. The dying out also in passing to the west of the distinctions so easily established in the eastern coal-fields, (Ranigunj, Jherria, &c.), where a three-fold sub-division of the true *Damuda* or coal-bearing rocks is obvious—a fact already fully indicated by Mr. Hughes, as far as the Bengal fields are concerned—has been shown by Mr. Medlicott to be entirely supported by the character of the rocks in the more western fields. And, at the same time, the co-existent fact of the considerable increase in the development of the group which occurs at the top of the series (the *Panchet* group), seems equally established. The entire group of the formations or series which in the east gives five well-marked sub-divisions *(Talchir, Barakar, Ironstone shales, Ranigunj,* and *Panchet)* becomes at only a short distance to the west only a three-fold series of the *Talchir*, the *Barakar*, and the *Panchet*. This was shown to be the case in some of the Bengal fields, and the same fact is more fully insisted on by Mr. Medlicott with reference to the country lying further west.

Although, so far as known, there seem good grounds for admitting this as giving the truest representation of the facts, it must at the same time be stated that the lithological character of each of these groups differ in the west and south from that of the typical rocks in the Ranigunj field and Talchir field. Even so near to Ranigunj as the Palamow (or Daltongunj field,) Mr. Hughes has shown that the *Barakar* rocks present a lithological character intermediate as it were between the true *Barakar* and the *Ranigunj* beds. And further, in the Bokaro field, he has pointed out the transitional passage of the *Ranigunj* beds into the *Panchets*.

With these facts, it would almost remain an open question, whether much of those upper beds, to which we are now disposed to assign the general name *Panchet*, may not represent, *in time*, the upper groups of the more eastern fields (*Ranigunj* beds, *Ironstone shale*). And the fossils contained would go to support this view. But the general mineral character very decidedly approximates more to that of the typical *Panchet* rocks, and throughout the entire area extending over many thousand square miles with well exposed sections, the absence of any deposits of coal, which are so valuable and abundant in the upper groups of the Ranigunj field, is an additional and strong reason why these rocks should be referred to the *Panchet* group rather than to the others. It might possibly solve the difficulty better in the first instance to establish an intermediate and distinct sub-division applicable only to a part of this upper group of rocks in the west, but this would perhaps only lead to greater difficulties, because this group must be localized, while all the facts point rather to a gradual passage of character over geographical areas, than to any definite sub-division. In any such large series, where the sub-divisions are not marked by material interruption, or change, of deposit, or by any long interval of time accompanied by the destruction of pre-existing beds, there is no possibility of drawing any trenchant line of division, for such does not exist. And it can, therefore, be only on a balancing of evidence that any part is placed in correlation with one sub-division rather than with another.

Mr. Medlicott has also brought forward additional proofs to show that, on the large scale, the present limits of these coal-measure fields coincide approximately with the original limits of deposition and are not the result of faulting, or even mainly of denudation.

This limitation of original deposition has long been the view held by Mr. Hughes (and by myself) with reference to the Bengal fields which he had examined, and Mr. Medlicott now shows how he considers it applicable to those in the west also.

There appear to me, however, wider and larger views of this variation in mineral character, and in succession of beds, as well as in limitation of area occupied, which must be worked out in greater detail before any definite conclusions be possible. They may, however, be indicated. All these successive beds, (possibly with the exception of the *Talchirs*) representing an enormous lapse of time, agree in one respect, that they seem to be purely fresh water (fluviatile or fluvio-lacustrine) or estuarine deposits. This fact alone involves the consideration of definite limits within which the rivers or lakes by which, or in which, they were formed were confined at the time of their deposition. This again would seem unavoidably to bring with it a very large amount of variation in each basin of deposition quite consistently with a general resemblance or agreement in the succession. It seems difficult, if not almost impossible, to suppose that coincidently with any great changes of surface level, &c., which may have affected the whole country, there were not also variations in each more limited area, or drainage basin of the then existing dry land. Thus it seems to me, we are naturally led, *à priori*, to look for a general persistence of type coincidently with a wide limit of variation in detail. And this, I believe, will go far to account for much of the variation we do find. The present distribution of these coal-fields in India, modified, as it undoubtedly has been, by the great destruction and denudation to which not only the coal-bearing, but all subjacent rocks have been subjected, appears to me to point also to this limitation to defined areas. Thus the Ranigunj, the Jherria, the Bokaro, the Ramghur, and the Karunpura fields all belong to the drainage basin of the Damoodah river. Itkuri (Eetcoora), and the Kurhurbari fields are in the basin of the Barakar, the largest affluent of the Damoodah, from which in the upper part of its course it is separated by the lofty ranges of Parasnath and the wide plateau of Hazaribagh. The Kasta deposits and the limited field near Dubrajpur and the Deogur fields are in the valley of the Adjai, and limited to it, while the valley of the More, further to the north, has its small field near to Soory. (In a wider view, all these rivers may be considered to have formed one general estuary at an early period). The Talchir field, near Katták, the detached areas of Talchir sandstones in the Sumbulpur country, and the Belaspur field, are limited to the Mahanuddy basin; the Palamow, the Singrowli, and South Rewah coals are all strictly confined to the Sone basin;—the Chanda field and the continuation of this field in detached areas down the Godavery valley, considerably below Dumagudiam, all are strictly confined to the basin of the Godavery and its affluents, while similarly the coal-fields of the Nerbudda valley are all limited to the drainage basin of that river.

In other words, it seems to me that there is very strong evidence to lead to the conviction (announced by me at the meeting of the British Association in December 1867, when speaking generally of the Geology of India), that the great drainage basins of this country were on the large scale marked out, and existed (as drainage-basins) at the enormously distant period which marked the commencement of the deposition of the great plant-bearing series to which I have referred.

In this point of view, local variations in the lithological type, and local variations in the thickness of the groups, and even their occurrence or non-occurrence, are only necessary consequences of the mode and limits of formation. And this will, I think, go far to account for these variations.

Mr. Medlicott has arrived at somewhat similar conclusions bearing on the limits of deposition of these beds as applied to some of the basins.

At the commencement of the present season, Mr. Medlicott proceeded to the Nerbudda valley, to work out more closely than had before been practicable the coal-bearing rocks in that area. When first visited, now more than twelve years since, no maps whatever existed of the Nursingpur and Hoshungabad districts, and it was necessary, in order to obtain any record, to carry out a general topographical sketch or survey concurrently with the geological examination. Within the last few months we obtained the finished revenue survey maps of these districts (Hoshungabad and Nursingpur), and I have at once taken advantage of them to ascertain with greater accuracy than was originally possible the distribution and contents of the coal-measure rocks there. The approaching completion of the line of railway between Jubbulpur and Bombay also rendered it urgently important that this should be done at the earliest date.

Mr. Willson examined in the early part of the year a large portion of the Jhansi and Lullutpur districts, tracing out the remarkable quartz reefs that exist in such numbers and of such size in that area, and mapping with care the limits also of the recent deposits. And he is at present engaged in the continuation of this work, so as to join on his geological boundaries with those already very carefully put in by himself in the Saugor and Dumoh districts and with those in the Gwalior country mapped by Mr. Hacket.

The terrible sufferings of the population in Jeypore and adjoining country from failure of their crops, and the consequences of deficiency of food, rendered it desirable that Mr. Hacket should not return for the present season to the work on which he had been there engaged. He has, therefore, been moved to Jubbulpur, where he will carry out the examination with the detailed maps now available of the south-east portion of the district, and connect it with Rewah to the north and east. In the beginning of the year Mr. Hacket traced out the boundary of the great Deccan trap area, from Neemuch across to the Beeas river, which line has since been embodied in the general map of the Vindhyan area accompanying the published report of Mr. F. Mallet.

Mr. Ball, in the early part of the year, carried out the examination of parts of the Singhbhum country, tracing out carefully the copper-bearing rocks and their limits. And since Mr. Ormsby's return in the autumn, Mr. Ball and Mr. Ormsby have both been sent to revise and bring up to the existing state of knowledge of Indian Geology the maps of Bhagulpur and Birbhum previous to final publication. These districts were among those earliest examined in this country. And since that time very considerable progress has been made in the distinguishing of the rock groups of India. The original examination of these districts had also been more than once necessarily interrupted by disturbances among the Sonthals and other causes, and it was therefore essential that they should be gone over again with a view to general revision.

Mr. Mallet, during the early portion of the year, was engaged in working out in detail, and with the advantage of new and better maps, the relations of the several groups of rocks which occur in the eastern portion of the Sone valley, and which there come between the Vindhyan formation and the gneissose rocks. The more important of his results have been embodied in the Report on the Vindhyan formation, published during the year, which is noticed further on. Mr. Mallet, as already mentioned, has obtained leave for one year, and left India in September.

Mr. W. Blanford rejoined the Geological Survey on his return from deputation as Naturalist and Geologist in connection with the Abyssinian Field Force at the beginning of November. He has taken up the careful examination of the Chanda district with the assistance of Mr. Hughes and Mr. Fedden. Of this district he had himself made a rapid reconnoissance in 1866 and furnished a sketch geological map, which, considering the very unfavorable nature of the country for any geological examination and the brief visit Mr. Blanford paid to the district, was marvellously accurate and good. Mr. Blanford then also was the first to realize the true nature of the coal deposits of the field, which had been searched out with untiring determination by Major Lucie-Smith, the Deputy Commissioner. The occurrence of these coals in this district in a geographical position singularly favorable for the supply of fuel to a very large area both to the west and south, and the considerable difficulties attending the investigation, rendered it highly important that the facts should be ascertained as quickly as possible. I have therefore moved up from Bengal Mr. Theod. Hughes, who has perhaps had more experience and detailed knowledge of the Indian coal-bearing rocks than any one on the Survey, and with Mr. Fedden he will act under Mr. Blanford, Deputy Superintendent. The work was allotted without delay. Mr. Blanford himself, in addition to the general supervision of all, has taken up the detailed investigation of the rocks which come below the coal measure series. Mr. Fedden has been sent to those above the same series, while Mr. Hughes will take up these coal-rocks themselves. The district is most unfavorable for detailed geological examination, being either more than usually covered with very thick deposits of clays and gravels (often cemented into a hard calcareous conglomerate), occasionally containing bones or fragments of bones of large animals, and all probably of the same general age as the similar conglomerates of the Nerbudda and Godavery valleys, *(Pliocene)*, or concealed by widely spreading jungles and forests often almost impenetrable. Mr. Blanford years since pointed out that it would be impossible to arrive at any satisfactory conclusions without actually boring in many places, and this actual testing of the ground is now being carried out successfully in conjunction with the general examination. Should the officers of the Survey be fortunate enough to preserve good health during the season, this year will see a large area thoroughly explored. As already mentioned, the late rains in October produced a good deal of fever and illness, and, as usual, the Survey parties have also suffered.

MADRAS.—The early part of the year (1869) was given by Mr. King and Mr. Foote to the completion of the geological area occupied by quartzites, slates, limestones, &c., which cover the larger portion of the districts of Kuddapah and Kurnool, and which appear, geologically, to represent in the south the older portion of the great Vindhyan series, to which allusion has already been made. This great area being complete in itself, that is, being surrounded on all sides by rocks of totally different ages and different mineral characters, will be treated of as one. And since the close of the field work, Mr. King has completed a general report on the entire area containing many thousand square miles. This report is now in preparation for the press; and will be issued during the present year. Mr. King took furlough-leave in September, handing over the Madras work to Mr. Foote. For the present season Mr. Foote has been directed to carry on the examination of the rocks, of the same mineral character, which appear under the great flows of the Deccan trap, and resting quite unconformably on the gneiss rocks in parts of the Raichoor Doab, the vicinity of Belgaum, and under parts of the ghats on the western coast. That they belong to the same general series as the rocks in Kuddapah and Kurnool there is no question, and it is hoped that Mr. Foote's acquaintance with the latter will enable him the more easily to identify them. This will connect with the Madras area the work already done by Mr. C. Wilkinson some years since in Rutnagherry and Sawunt Warree, but which was unfortunately left unfinished, when that gentleman was obliged to resign his connection with the Survey, as his health could not bear the great exposure unavoidably entailed by his geological work. This work will also, I think, give us a second complete section (geological) across the Peninsula.

I have had occasion already to notice the decease of Mr. C. Oldham, which untimely event, and Mr. King's absence on leave have reduced the Madras party for the present season to only one, Mr. Bruce Foote.

BOMBAY.—The Bombay party of the Survey continued the examination of Kutch as reported last year. This was completed before the close of the working season of 1869, and Mr. Wynne and Mr. Fedden both deserve much credit for the zealous and earnest spirit with which they carried out this work in a very difficult and in many ways very inaccessible district. Mr. Wynne has subsequently, during the monsoon, prepared a very admirably executed map of the whole of Kutch, and has embodied his own and Mr. Fedden's researches in a general report, accompanied with many excellent and well-drawn sketches. This map is on the same scale as the Atlas of India, namely, 4 miles = one inch, and it will scarcely be practicable to show the detail of the geology on a smaller map, although the publication of this large plan will be difficult.

At the commencement of the present season, as soon as it was practicable to leave Kutch, Mr. Wynne proceeded, as ordered, to the Punjab to take up the detailed examination of that province, while Mr. Fedden proceeded to Bombay, and joining Mr. Blanford took up, under his instructions, the examination of parts of the Chanda and Woon districts, in which he is now engaged.

It had long been my desire to carry out a careful examination of the Punjab, which offers to the Geologist many points of great interest, as well as promise of valuable mineral products. But the pressing demands for geological enquiry in other directions have always hitherto prevented any of the staff of the Survey from being located there. It was, therefore, with pleasure that I found it practicable to send Mr. Wynne there this season, and I doubt not he will exhibit the same zeal and ability there as he has elsewhere. I have asked hi special attention to the relations of the beds from which petroleum is obtained or likely to obtained.

BURMAH.—Mr. W. Theobald has, as anticipated in last year's report, completed the general examination of the Prome district up to the frontier of British Burmah, so far as that lies to the east of the Irawadi. He has this season taken up the country lying the west of the river in the same parallel, and I hope the season will see it completed. this part of the district, nummulitic rocks (limestones, &c.,) occur and form an interesting study. They may be found to contain petroleum, as they occasionally do elsewhere.

PUBLICATIONS.—The first part of the seventh volume of the ***Memoirs of the Geological Survey of India*** contains a full report on the area occupied in North-Western India by the great series of rocks, to which the name VINDHYAN was first given by myself in 1856. Stretching along the northern escarpments of the Nerbudda valley, passing across the district of Jubbulpur, and forming the whole of the Rewah country north of the Sone, this great series extends in a continuous mass far into Bengal, where the picturesque cliffs of the Rhotasgurh hills form its steeply scarped limits on the left bank of the Sone. Returning towards the west by Sasseram, Chunar, Mirzapur, and a little south of Allahabad, the boundary thence stretches in a great sweeping bay or curve to the south by Kirwee, Bijawur, and crossing the Beas river, trends again north to Gwalior and Agra, and Futtipur Sikri, whence the line again trends to the south and extends to near Neemuch. The rocks belonging to this widely extended and important group constitute one of the most remarkable and interesting series in all India. They become also still more important to the Indian Geologist when he finds representatives of the same great series covering immense areas in the Madras Presidency (Kuddapah, Kurnool, &c.), stretching northwards along the flanks of the ghats, and up the Godavery country, until in Berar and the adjoining parts of the Nizam's dominions, and again in Bustar and Chutteesgurh, they constitute the rocky basis of very extended districts. They are divisible into several different groups characterized by peculiar lithological distinctions, and throughout the whole area described present a wonderful constancy of mineral composition. Mr. Fred. Mallet, who had himself examined much of the area in N. W. India occupied by these rocks, has combined with his personal observations the labours of others, and has given a connected history of the entire series in this part of the Memoirs.

I have always found it exceedingly difficult to lead to a just conception of the immensity of the areas we have to deal with in this country. And it may be useful to draw a comparison here which may tend to a realization of the facts. The small map, which accompanies the report of Mr. Mallet, (a reduction from the larger scale maps used in the field) just noticed, represents an area quite as large as England and Wales; while all the lines of geological division and sub-division shown on it have been actually traced out by detailed examination. The previous part of the *Memoirs*, the last part of Volume VI, contained also a geological map of quite as extended an area, that is, geological maps and reports have been published within twelve months, exhibiting the structure of a country larger in area than the whole of Great Britain and Ireland. And it should be added of a country regarding the structure of which nothing trustworthy was known previously to the commencement of the Geological Survey.

The same part of Volume VII contains also a continuation for 1868 of the annual returns of the quantity of COAL raised in India in continuation of similar returns which I had already published for the years since 1857. The full details will be seen in the tables given.

There is also, in the same part, a careful description of the very interesting area near Cherra Poonji in Eastern Bengal by Mr. Medlicott. As stated in my last report, Mr. Medlicott enjoyed the advantage of visiting these hills at the only time of year in which it was possible for any one, without certainty of serious illness, to visit the lower valleys, which are deadly in the rainy season. He has thus been able to clear up much that was unknown, and the consequence has been a considerable modification of the views originally taken of their structure. Mr. Medlicott has also been able to carry out the separation of the tertiary and cretaceous rocks, the necessity for which, as established by fossils, was indicated by me in 1863, (Quar. Jour. Geol. Soc., Lond. vol. xix, p. 524). His brief memoir will prove a valuable basis on which to carry out the detailed examination of the adjoining hills.

Reports on the Kurhurbari coal-field and on the detached and small fields near Deoghur in Birbhum are ready; their issue being only delayed by the time required for colouring the geological maps.

Of the *Palæontologia Indica*, a part or fasciculus of which was due in October last, I have not issued any part. Several complaints as to the loss and injury sustained in consequence of the issue of this valuable series in small fasciculi having reached me, and desire having been expressed that they should be sent in larger parts, or volumes, or half volumes I have thought it better to defer the issue for a little until a larger part can be published at once. The four parts, therefore, for the year 1869-70, the last of which will be due in October 1870, will be issued during the year before October, and will constitute half a volume. The plates for all these are quite ready, and separate fasciculi could be issued now, but, for the reasons here given, it is thought wiser to delay a little and give four parts in one, as was done before.

The *Records of the Geological Survey*, which, as announced, are intended to convey a notice of the current work of the Survey, shorter papers, and abstracts of papers which cannot be published in detail at once, with analyses of works bearing upon the Geology of India, have punctually appeared at the stated intervals of three months. In the numbers for the past year, we have given to the public descriptions of the geology of the rich and productive valley of Berar; sketch of the Geology of Kutch; of the Shillong plateau (since published in detail); of the Kuddapah and Kurnool districts in Madras, (of which detailed report is in press); on parts of Prome in British Burmah; on the general relations of the metamorphic rocks of Bengal; in palæontology, a careful description and plate of the fossil *Pangshura* (*Emys*) *tecta*, and other *Chelonia*. These are of very high interest, as they are truly identical with the same species, now living abundantly in this country, while the remains described were found along with remains of animals which have long ceased to exist in India, (*Hippopotamus*, *Sivatherium*, *Mastodon*, *&c.*). Bearing on the practical applications of Geology, we have notices of gold in Singhbhum: of the mineral statistics of Kumaon, where a considerable amount of copper is still raised by the inhabitants; and on the coal-fields of the Central Provinces: while to meet the general interest excited in the history of the Nicobar Islands, and to answer many enquiries made regarding their geology, I have published a translation of the most recent and valuable contribution to their geological history, which having appeared in German, as a part of an expensive and not generally available series of publications, containing the researches of the scientific expedition which the Austrian Government sent round the world in the "Novara" (1857-59), was not accessible generally to the public here. Full lists of the additions to our library here, of which so large a portion consists of exchanges with scientific institutions and societies in other countries, are also regularly given in the *Records*.

In addition to the ordinary current work of the Survey much additional labour has been undertaken in furnishing brief notices or sketches of different districts or provinces for district officers, and lately more especially for the officers charged with the editing of the several Gazetteers now in preparation. These notices are necessarily required to be brief, but the briefer they are, the more time and trouble they cost. I have further undertaken to continue to supply these notices from time to time, not only for Bengal, but for other parts of the country. Copies of geological maps, and sketch geological maps have also been given to several public authorities and others, who have been interested either in investigations connected with the mineral resources of the country, or for sanitary purposes. Of the value and utility of these maps, we have received cordial acknowledgments from all.

LIBRARY.—During the year just past, 883 volumes or parts of volumes have been added to our library. Of this number 393 were presented by other institutions or societies, or were received in exchange for the publications of the Geological Survey. A full list, as already mentioned, is given of the additions every three months in the Records. As usual, a list is here appended showing all the societies or public institutions from which donations or exchanges have been received during the year 1869.

As with the collections, so also with our books, maps, &c., we are most seriously inconvenienced by the very limited space available for their exhibition or preservation—a difficulty which there is at the present no means of obviating.

MUSEUM.—So far as there has been any room, additions have constantly been made to the collections exhibited in the Museum; and all practicable means are adopted to prepare other series for exhibition, whenever it may be possible to accomplish this. More than 20,000 specimens have passed through the Curator's and Assistant Curator's hands, and have been entered and catalogued for reference during the year. But many of these had to be packed up again, there being no place to keep them otherwise. Cases have been procured as quickly as possible for the additional rooms noticed in last year's report, but they are not all ready yet.

METEORITES.—Our noble collection of Meteorites maintains its excellence. During the twelve months past, we have had additions of a good specimen of the Khetree fall (February 1867), for which we are indebted to Mr. D. Waldie of Calcutta, and specimens of the Ornans fall (July 1868); of that which occurred at Sclavetič in Croatia (May 1868); and of the mass which fell at Krähenberg, near Zweibrücken (May 1869). For the last three we are indebted to Dr. Tschermak of the Imperial Mineral Cabinet at Vienna.

As customary, an Index map, on a small scale, is appended, showing roughly the present state of progress of the Survey; as also a list of those societies or public institutions from which we have received publications, during the twelve months, in exchange for those of the Geological Survey of India.

T. OLDHAM,

Supdt. of Geol. Survey of India and Director of Geol. Museum, Calcutta.

CAMP, CHANDA DISTRICT, *January 3rd*, 1870.

List of Societies and other Public Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1869.

BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOMBAY.—Geographical Society.
BOSTON.—Society of Natural History.
„ Museum of comparative Zoology.
BRESLAU.—Schlesische Gesellschaft für vaterlændische Cultur.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
CORNWALL.—Royal Geological Society.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GÖTTINGEN.—Königl. Gesellschaft der Wissenschaften.
HALLE.—Natural History Society.
JUBBULPORE.—Government School of Industry.
LAUSANNE.—Société Vaudoise des Sciences Naturelles.
LONDON.—Royal Geographical Society.
Royal Society.
Royal Asiatic Society of Great Britain and Ireland.
Geological Society.
Geological Survey of Great Britain and Ireland.
Society of Arts.
MADRID.—Royal Society.
MANCHESTER.—Literary and Philosophical Society.
MOSCOW.—Société Impériale des Naturalistes.
NORWAY.—Royal University of Christiania.
PALERMO.—Scienze Naturali ed Economiche.
PARIS.—Academy of Sciences.
„ Comm. des Annales des Mines.
„ Société Géologique de France.
PHILADELPHIA.—American Philosophical Society.
„ Franklin Institute.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Essex Institute.
TORONTO.—Canadian Institute.

TURIN.—Royal Academy of Sciences.
VICTORIA.—Royal Society.
" Philosophical Institute.
" Govt. Geological Survey of Victoria.
VIENNA.—Kais. Akad. der Wissenschaften.
" K. K. Geologische Reichs-Anstalt.
WASHINGTON.—Smithsonian Institute.

Governments of India, Madras, Bombay, Bengal, N. W. Provinces, Punjab; Chief Commissioners, Oude, Central Provinces, British Burmah.

NOTES ON THE GEOLOGY OF THE NEIGHBOURHOOD OF MADRAS,—by R. BRUCE FOOTE, Esq., F. G. S., Geological Survey of India.

The greater part of the Madras district lying north of the Palar river and south of the Pulicat lake is occupied by rocks of the secondary, tertiary, and recent ages, the remainder of the area being taken up by metamorphic rocks forming part of the great gneissic series of Southern India.

The topographical features of this part of the Carnatic are very simple, the ground rising from the coast westward up to the foot of the Eastern ghâts and their outliers, in a very gradually inclined plane which I will call the Madras area. The surface of this plane is varied only by the shallow valleys of the Narnaveram, Cortelliar, and Palar rivers, the latter forming the southern boundary of the tract of country now under consideration. In the north-western part of the district the inclined plane is broken by two groups of hills, the Sattavedu and Alicoor hills, to the west and north-west of which, but just beyond the boundary of the country now to be described, rise the Naggery mountains, which are lofty and conspicuous, but perfectly detached outliers of the Eastern ghâts. The south-eastern corner of the inclined plane is dotted by a number of low, but picturesque, ridgy gneiss hills.

The northern, central, and south-western parts of the Madras area are occupied by the stratified rocks, roughly speaking, the southern and south-eastern parts by the metamorphic rocks, a narrow belt of which must be included all round the western boundary of the area of the stratified rocks.

CLASSIFICATION OF THE ROCKS.

The following tabular statement illustrates the various groups into which the rocks of the Madras area have been classified:—

Recent or quaternary .	Blown sands. Alluvium, marine, and fluviatile. Laterite and Conjeveram gravels.
Tertiary ...	... Gritty sandstones. ? Cuddalore sandstones.
Secondary ...	... (Cretaceous ?) Jurassic, Rajmahal plant beds.
Submetamorphic	... Cuddapah group.
Metamorphic ...	... Gneissic series.

The Blown Sands.—These sub-aerial deposits are of no great extent or importance, as they form merely a fringing ridge to the beach. To the south of Madras they are largest at, and to the south of, Covelong (Kovilam of the natives). North of Madras they attain their greatest height, between 40 and 50 feet, at a place called Chintamanikovil, where they have nearly covered up the Kovil (Hindu temple).

The greatest width attained by this coast ridge may be about a mile, but it is generally much less, and the amount of drifting inland is not of any real importance, and easily stopped by plantations of suitable trees, *e. g.*, Casuarinas, Palmyra palms, Screw pines, and Cashewnut trees, all of which flourish near the coast.

The alluvial formations.—These are of two classes, marine (including estuarine) and fluviatile, but they are nearly undistinguishable in character, and at many points graduate into each other imperceptibly.

Their general character, as seen at the surface, is that of pure, or nearly pure, silicious sands, but beds of black, blue, or grey clay occur largely below the surface in the marine alluvium near Madras; these are, however, much less frequent in the fluviatile alluvium higher up the river valleys. The greatest depth to which the marine beds have been pierced by sinkings is 55 feet, when the gneiss was reached. In the marine and estuarine beds along the coast many of the clays are largely filled with shells, all of living species, but in a sub-fossil condition. Such marine beds are known to extend two to three miles inland, but I could not ascertain whether they had been penetrated by any sinkings further inland.

The river alluvia are of more interest than the marine, because they afford evidence of some remarkable changes within the human period in the courses of several of the principal rivers in the district. Lithologically, the fluviatile alluvia are of no interest, for they consist, as a rule, of nothing but coarse, gritty, loose, silicious sand. Gravels or clayey beds are rare, and organic remains are hardly ever met with, excepting a few *Helices* and fresh water shells, (all of living species), in thin beds of reddish loam.

The changes in the course of the rivers above referred to are four in number, and concern three rivers, the Palar, the Cortelliar, and the Naggery river, but I will only notice the two most important here.

The Palar now flows into the sea 42 miles south of Madras, but it, or a large branch of it, formerly flowed down what is now the alluvial valley of the Cortelliar, and debouched into the sea, somewhere to the north of Madras, probably between Ennore and Pulicat. The present Cortelliar valley is very disproportionately large as compared with the river which runs through it in a rather deep channel.

The present valley of the Palar is still more disproportionately small as compared with its river; the two alluvial valleys join, or rather diverge, at a place about 10 miles east of the town of Arcot. A stream is even now connected with the Palar just at the fork by which water is still carried down the Cortelliar valley for many miles and eventually falls into that river.

This stream is considered by the natives to be the old Palar and bears a Sanscrit name, Vridachara nuddee or old milk river, the Tamil word Palar also signifying milk river. A similar change, of course, has occurred to the Naggery river, which in former times fell into the Narnaveram river, close to the Ramaghiri mountain, at Naglòperam. The Naggery river was diverted from its old course at a place about two miles east by south of the town of Naggery, and made, by the cutting of a channel about half a mile in length through gneissic rocks, to turn to the south-east instead of flowing due east and east by north and to fall into the Trittang river, which joins the Cortelliar a few miles further east. The broad alluvial valley which now runs between the Naggery mountain ridge and the Alicoor hills is in consequence of this change drained only by small streams and artificial channels.

I could not obtain any information on this point from the enquiries I made on the spot, but from the appearance of the cut through the neck of gneissic rock above described, I think the change of the river course was the result of human agency. Like the alluvium of the Palar river the alluvia of the Naggery river (both in its old valley and along the newer channel as far as its junction with the Cortelliar) and of the Narnaveram river consist almost entirely of coarse gritty sand; clay beds are rare, but where met with are of black color and regur-like texture. All the rivers named appear to be still cutting their channels deeper and deeper every season.

Lateritic formations.—The formations classed under the above heading are of three principal kinds, namely, clayey conglomerates, gravels, and sands which occur distributed over nearly the whole of the area under consideration.

Their occurrence is, however, not so much in continuous spreads as in detached patches, many of which are but of small size, though some occupy important areas from one hundred to two or nearly three hundred square miles in extent.

These larger areas occupy, as a rule, the higher grounds lying between the different river valleys; the small patches occur at similar levels and are evidently outliers left by partial denudatory action by which the once continuous lateritic deposits have been thus broken up.

The thickness of the lateritic formations is very small when compared to their superficial extension. They rarely attain a thickness of 12 feet or upwards.

The three principal kinds of rock above enumerated which make up the bulk of the lateritic series, namely, clayey conglomerates, gravels, and sands, are found constantly graduating into each other in such a manner that they can only be regarded as parts of one and the same deposit, however various the appearance of the different members.

In the Madras area, and to the north of Madras in the Nellore district, the character of the lateritic formations is considerably different from that of the representatives of the same series further south in Trichinopoly and South Arcot districts, the difference consisting in the much greater frequency of conglomerates and in the presence of large quantities of quartzite pebbles enclosed in the conglomerates. This peculiarity depends on the proximity of the quartzite rocks of the Cuddapah series, which attain their southernmost point in the Naggery mountains, and even more perhaps on the extensive destruction of the much younger conglomerates of the jurassic series which were mainly composed of pebbles and boulders of such quartzite and were of great thickness. The laterites of South Arcot, Trichinopoly, and Tanjore, on the contrary, do not, so far as known, contain any quartzite whatsoever, but only fragments of gneissic rocks, and these but very rarely. The nearer the laterite of the Madras area approaches to the Alicoor and Sattavedu hills, which are entirely composed of the coarse jurassic conglomerate above spoken of, the larger do the quartzite and other pebbles it encloses become. In some of the laterite sections indeed near those hills the conglomerate is so coarse that few of the enclosed pebbles are less in size than a man's head, and many very much larger; some, indeed, though perfectly smooth and well rounded, of such size as to deserve the name of boulders.

In such conglomerates the matrix of ferruginous clay iron stone is almost masked by the included masses.

Near the sea, however, as at the Red Hills, a few miles north-west of Madras, the included quartzite pebbles are small and not numerous, and the conglomeratic character not everywhere visible. Where such is the case, the peculiar characteristics of typical laterite, namely, its ferruginous character, its permeation by tubular and vesicular cavities filled with pale colored sandy clay, and lastly, its hardening and becoming coated with a glaze when exposed to atmospheric influences, are seen to perfection.

The laterite gravels frequently contain pebbles of quartzite and gneiss mixed with the pisiform ferruginous pellets in varying proportion according to their proximity or distance from the older quartzite yielding rocks. The sands associated with the lateritic conglomerates and gravels show considerable variety in texture and color, the latter depending on the percentage of iron. They not unfrequently contain a large quantity of clay, and are then apt to cake and harden, but without the excessive fissuring noticeable in purer clays. These sandy beds are frequently found overlying the highly ferruginous beds and form to a great extent the soil of the laterite areas.

The Conjeveram gravels.—In the south-western part of the Madras area the high grounds north-north-east and north-west of Conjeveram are covered by a peculiar quartzite gravel formation occupying the same relative position as the true laterite further to the east and north, but distinguishable from it by the absence of ferruginous matter, and consequently by its pale color. This change in mineral character (supposing the Conjeveram gravels to belong to the laterite period) takes place a little westward of a line drawn from Wallajahbad due north to the alluvium of the Cortelliar valley, but unfortunately no section occurs showing the two formations in juxtaposition.

Both have so far proved unfossiliferous as far as true organic remains are concerned, but both appear to contain implements of human manufacture in the shape of axes and spear heads made of *chipped* quartzite pebbles and of the same types as those occurring in the gravels of Western Europe. I have given the name of the famous old town of Conjeveram to this non-ferruginous gravel deposit, from its occurring, so far as I know, only within the Conjeveram taluq.

CUDDALORE SANDSTONES.

Underlying the lateritic formations in the northern part of the Madras district is a gritty sandstone of white or drab color sometimes slightly mottled with rusty spots. This sandstone, which is well exposed only in the cliffs on the south side of the Cortelliar river, six miles north-west by north of the Red Hills, bears a strong resemblance lithologically to some parts of the Cuddalore sandstones as seen near Cuddalore, and like them appears completely unfossiliferous. In the Cortelliar cliffs the following section is exposed :—

Lateritic conglomerate	3 to 4 feet.
Mottled gritty sandstone	6 "
Quartzose grit of buffy white and brown colors, becoming whiter and coarser grained downwards, very friable; beds divided by thin partings of Kunkur	30 to 40 "

The base of the section is unfortunately entirely obscured by fallen masses, or by the water which here remains in a deep pool at the foot of the cliffs.

It is not known what underlies these beds, so they can only be provisionally regarded as representatives of the Cuddalore sandstones. The gritty sandstones west of Poonamallee which Mr. H. F. Blanford was disposed to refer to the same supra-cretaceous position have yielded a few fossils of unmistakeably Rajmahal (jurassic) character.

No representatives of the cretaceous group being as yet known to occur within the limited Madras area I pass on to review the different members of the

RAJMAHAL OR JURASSIC ROCKS.

Although occupying superficially a lesser area than the lateritic rocks, the Rajmahal beds are of infinitely greater geological importance and deserve considerable attention.

Like the lateritic rocks, the Rajmahal beds are scattered about over the country in a number of detached areas and patches divided from each other by alluvial valleys or by bands of overlying lateritic strata that have escaped denudation. From this broken up condition of the formations added to the absence of really good sections it is difficult and in some cases almost impossible satisfactorily to correlate the different formations occurring in several patches.

For convenience sake it will be better to consider the several distinct patches in four groups, ignoring as much as possible the intervening covering formations of younger date. It is only in the three northern of these four areas that the base of the Rajmahal beds is seen, resting on the gneissic rocks along the foot of the western flanks of the Sattavedu and Alicoor hills and of the low plateau east of the Arconum railway junction.

In the Sripermatoor area the base of the series is nowhere seen owing to the great thickness of the surface deposits. Owing partly to the peculiar shape of the ground, but still more to the general softness of the rocks and to the consequent enormous accumulations of debris covering the surface, no section exists showing the true relations of more than small portions of the Rajmahal series, which renders any stratigraphical sub-division of the entire series very difficult and uncertain. A provisional sub-division into two groups has, however, been proposed, based mainly on lithological differences.

To one group consisting of coarse well consolidated conglomerates and sandstones the name of Sattavedu group has been given, from the fact of these beds having been first studied–by my colleague, Mr. King–, in the Sattavedu hills.

The other group, consisting of shales, clays, and gritty sandstones and unconsolidated conglomerates, we have called the Sripermatoor group, from its most important members occurring under and around the town of Sripermatoor.

The Sattavedu Group.—In the Sattavedu area the entire series of rocks met with consists of alternate bands of conglomerates and sandstones many hundred feet thick. These beds extend southward into the Alicoor hills area (under the valley of the Narnaveram river) and form the eastern and loftier half of the hill group. The entire eastern base of both the hill groups is covered up by lateritic conglomerates and sand, by which any extension to the east of this series is completely masked.

The chief petrological character of the members of this series is the prodigious coarseness of the conglomerates which are made up of large well rounded smooth pebbles of quartzite with a small number of similarly waterworn masses of granitoid gneiss firmly cemented together by a varying cement which is sometimes argillo-ferruginous, ferrugino-arenaceous, or silicio-calcareous. In some of the sandstone beds in the Sattavedu hills Mr. King discovered the few plant remains, amongst which was part of a recognizable *Dictyopteris* frond, proving the true Rajmahal character of the beds which contained it. In the southern extension of the same beds in the Alicoor hills no fossils were found. The sandstones are mostly rather gritty in texture and only occasionally sufficiently compact to be useful as building stones.

Sripermatoor Group.—Apparently underlying these Sattavedu beds in perfect conformity are certain conglomerates, gritty clays and shales which form the western and southern parts of the Alicoor hills, and which differ from the beds of the Sattavedu series in being soft and quite uncompacted and of white or grey instead of brown and reddish colors. Even the coarsest conglomerate beds at and near the base of the series are soft, the pebbles and boulders of quartzite and gneiss, instead of being bound together by some firm cementing material, merely lie imbedded in a very friable, more or less clayey, grit consisting of quartzose debris derived from the gneissic rocks. Flanks of the hills consisting of these unconsolidated rocks are deeply covered by debris which is cut through by only a few rain-gullies of recent origin, and it is these only which afford sections of the undisturbed rocks. Many of the gullies, however, do not even cut through the thick coating of debris and rain wash. No section was found showing these unconsolidated beds in contact with the consolidated Sattavedu beds where they approach each other in the centre of the Alicoor hill group, but as far as the rounded outlines of the hills at that point serve to guide the eye there is an undoubted dip of the softer beds under the hard conglomerates of the Sattavedu series. No sign of any fault between the two series could be traced, but a fault might well exist and yet be perfectly masked by talus and debris. The nearest visible point of approach of the two series is a short narrow east and west ridge abutting at right angles against the hard basement-conglomerate bed of the Sattavedu series, which bed here forms a prominent north and south ridge, succeeded to the eastward by several other ridges, corresponding to as many great conglomerate beds. The valleys running down north and south from the cross ridge above mentioned are the two principal valleys in the central mass of the hill group, and the depth to which they are excavated is due to the greater softness of the underlying beds as compared with the overlying series. The southern part of the Alicoor hills, called by the natives the Naikenpolliam hills, is apparently composed only of the unconsolidated beds which have trended in the direction of their strike from north and south to west-north-west and east-south-east.

The basement bed at the south-west of the Alicoor area near the village of Naikenpolliam contains included masses of conglomeratic quartzite of such tremendous size—800 to 1,000 cubic feet in bulk—that they suggest the idea of their being the relics of the basement bed of the Cuddapah rocks, which are so splendidly represented about eight miles to the north-west in the tremendous cliffs of the Naggery ridge, parts of which have a vertical face of 1,000 feet high.

Glacial agency being inadmissible in so southernly a latitude, except on exceedingly strong evidence, the only probable explanation remaining is the one above suggested, which derives great probability from the fact that, on a far smaller scale indeed, similar masses of gneiss are included in situ in the basement bed of the Rajmahal plant beds at Ootatoor and elsewhere in the Trichinopoly district. These great quartzite masses, it is true, are not seen to be resting on the gneiss surface, but the latter can only be a few feet further down the slope. The inclusion of gneiss blocks in the basement bed of the Rajmahal series is to be seen only a few miles to the south in the banks of the Naggery river at Chittapuram. Numerous plant remains of unquestionable Rajmahal species were found in the principal section at the south-west end of the Alicoor hills. Amongst these plant remains were parts of *Tæniopteris*, *Dictyopteris*, *Palæozamia*, and *Pterophyllum*, and *Poacites*-like stalks.

Unfortunately from the friable nature of the clay bed in which they occur the majority appear to have become unrecognizable in drying, though, when freshly extracted from the matrix even the most delicate venations and nervures were plainly visible.

On the south side of the Naikenpolliam ridge the lower members only of the series appear to be represented; they consist of unconsolidated conglomerates of various degrees of coarseness, gritty sandstones and micaceous sandy shales, exposed in a few streams and a great many well sections.

The only section which yielded fossils was one on the north bank of the Naggery river opposite to Chittapuram, where two beds of rather friable sandstone were found to contain plant remains, amongst which fragments of *Tæniopteris* and *Dictyopteris* were identifiable.

On the opposite side of the river in the Pyanoor area the same beds reappear, and are there seen to be very low down in the series, in fact only a few feet above the basement bed, which here includes, or rather is deposited around and among, sundry large masses of syenitoid and gneissic rock. These sandstones with micaceous shales and sundry conglomerate beds of the usual unconsolidated type extend hence throughout the Pyanoor area, as proved by the numerous well sections, which everywhere pierce the superincumbent lateritic conglomerate.

The connection between the beds occurring in the Pyanoor area and those lying within the Sripermatoor area, 12 miles to the south-east, is not clear owing to the difference in petrological characters and to the insufficient evidence afforded by the organic remains. As far as the relative topographical position of the two areas affords any clue it is in favor of the beds of the Sripermatoor area, being simply an extension of those in the Pyanoor area, the difference in mineral character of the respective beds being probably due to the more littoral character of the Pyanoor beds as compared to the Sripermatoor beds, which though not to be considered as deep-sea deposits, yet appear to have been formed at considerable distance from the land of the period. This view is favored by the lithological character of a small series of Rajmahal beds exposed in a section lying about half way between the Pyanoor and Sripermatoor areas.

The most important member of the series in the Sripermatoor area is a white shale, the plant bed *par eminence*, resting on whitish friable gritty sandstone, which is in all probability the basement bed over a great part of the area. In the southern part of the area there is another series of grey clays, reddish sandstones, and buff sandy shales, whose position with reference to the plant-shale could not be ascertained in the absence of any section showing the two series.

The area occupied by the plant-shales is, roughly speaking, a rectangular basin about eight miles long from north to south by four from east to west, formed by the junction of several shallow valleys sloping very gently eastward. Several low hills rise out of the basin and are capped with laterite. The town of Sripermatoor stands in the north-west corner of the basin, which is surrounded by rising ground, the edge of which is here and there slightly scarped. To the south-east, however, a mere roll of the ground occurs much obscured by surface soil, and beyond this the grey clays appear. The plant-shales are apparently continuous all over the basin-like area, and appear to form only one bed which rolls about very slightly at low angles, or is horizontal. The shale is white, pale-grey, or buffy-drab in color, with in one or two places a little reddish or purplish mottling. The plant remains occur scattered through the mass in a fragmentary condition, as if they had been torn off by stormy winds and then drifted out to sea. In many places they are mixed up with remains of marine animals, *e. g.*, at Amarambode and Valerie.

The richest collections of fossils were made in the north-east corner of the basin where the two sections above named yielded specimens of nearly every species in the Rajmahal beds of the Madras area. In the western part of the basin animal remains were rarely found, indeed plants were everywhere more frequent than animal remains. Of the plants several species have been recognized as identical with species from the Rajmahal beds of Bengal and Cutch. These are *Palæozamia Cutchensis* and *acutifolium* and a *Dictyopteris*. The following genera of plants appear also to be represented among the specimens collected by myself: *Taxodites (?), Pterophyllum, Tæniopteris, Stangerites, Pecopteris, Lycopodium (?), Poacites*, and parts of exogenous stems perfectly silicified.

The animal remains which I discovered and collected included a considerable number of bivalve shells which, according to Dr. Stoliczka, belong to the genera "*Leda, Yoldia, Tellina, Psammobia, Lima, Pecten, &c.*, all forms with a remarkably thin shell, and the allies of which are usually found living on sandy ground in from eight to ten fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but *none* appear to be specifically identical".*

Besides the above were several small *Ammonites* referred by Dr. Stoliczka to the "*Dentati*" group (but unfortunately not sufficiently well preserved for specific identification); one a singular conical chambered shell, (? a phragmocone) of apparently cephalopodous origin, and some fish scales.

* See 'General results from an examination of the Gastropodous fauna of the South Indian Cretaceous deposits, by Ferd. Stoliczka, Ph D., F. G. S, Palæontologist, Geological Survey of India, page 59, in Vol. I of Records, Geological Survey of India.

Reference has already been made to the different lithological character of the rocks occurring in the southern part of the Sripermatoor area and to the absence of sections by which to determine the relationship of the two sets of beds. The series of beds here met with consists of white, grey-buff and black sandy clays, and brown, buff, reddish-purple and white gritty sandstones. One of the pale-buff sandy clays contains remains of *Palæozamia* and *Stangerites*. None of the sections show the base of the series. From its topographical position and petrological character I am inclined to think that this series underlies the great "plant-shale" bed.

Of very similar character and probably occupying the same relations to the "plant-shales" is a series of gritty sandstones and shales exposed in a fine section made by an artificial channel running into the great Chumbrumbaucum tank on its north side. As this section lies two miles outside of the Sripermatoor area and the intervening space is obscured by the laterite, the position of the series here seen relatively to the "plant-shales" can only be guessed at. The Rajmahal character of these beds is proved by the finding of a fragment of a *Dictyopteris* in one of the lower beds of shaley sandstone.

To the south-west of the Sripermatoor area the Rajmahal series appears to extend to some four miles beyond Conjeveram, for shaley and sandy beds of precisely similar character underlying the Conjeveram gravels are to be seen in several well sections. The most westerly point at which unquestionably Rajmahal plant remains were found was one mile to the south-west of Rajah's Choultry.

In conclusion I may point out that these Rajmahal beds of the Madras area contrast in several respects with those of Bengal and Cutch. The Madras Jurassic, or Rajmahal, beds contain no carbonaceous matter, which in their equivalents in other parts of India occurs so largely as to form coal seams. Nothing but silicified wood has been found in the Madras beds, and unlike the Bengal beds, in the Rajmahal hills, with their great intercalated trap flows and the Cutch beds, which are overlaid by trap flows of tertiary age, the Madras series is nowhere penetrated by, or overlaid by, igneous rocks of any kind, nor in the least degree metamorphosed. Another contrast, but of less importance, is, that unlike the Cutch beds, which are often of gay and bright colors, the Madras beds are remarkable for the dullness and sobriety of their coloring, a remark which applies also to their representatives in the Trichinopoly and Nellore districts.

THE SUBMETAMORPHIC AND METAMORPHIC ROCKS.

These demand hardly any notice in this place. The younger or sub-metamorphic series—the Kuddapah group—does not come within the area treated of, except in one, and that possibly a doubtful case (see page 11). The metamorphic rock series—the gneiss of Southern India—also presents little of interest locally; near the coast it consists of alternating bands of quartzo-felspathic and hornblendic beds which run to some extent parallel with the coast line. Further inland to the westward of the laterite and Rajmahal areas, the gneiss is more highly crystalline and largely granitoid or syenitoid in structure, and is traversed by a few trap dykes intruded prior to the deposition of even the Kuddapah rocks.

ON THE ALLUVIAL DEPOSITS OF THE IRAWADI, MORE PARTICULARLY AS CONTRASTED WITH THOSE OF THE GANGES,—by WM. THEOBALD, JUNR., ESQ., *Geol. Survey of India.*

It may fairly be presumed that the origin and growth of those extended alluvial deposits, forming the plains through which the more important rivers, carve their way to the sea, were, in each several case, very similar, and that the history of the deposition of the "loess" of the Mississippi valley was but little different from that of the "loess" of the Rhine. Each river system of course has its particular history, recorded in the alluvial deposits of its basin, which, in some cases, afford a simple, in others an intricate, record of the geological vicissitudes the area has undergone, and in tracing this record we are not unfrequently brought in contact with problems far more intricate and extensive in their bearing, than the apparently uninteresting character of the beds would suggest, and we have here in India in the "loess" of our larger river basins, the same phenomena to account for, which have so exercised the ingenuity of Geologists in the case of the "loess" of the Rhine.

In every large river basin two distinct alluvial deposits will generally be met with, and this, though it may seem a somewhat obvious fact to lay much stress on, has nevertheless been overlooked in some instances, where its admission was necessary for the true explanation of the geology of the district. One such instance is afforded in Mr. Fergusson's paper in the Quart. Geol. Jour., Vol. XIX, 1863, where the author, from not properly grasping this fact, is betrayed into advocating a theory of elevation of the beds supporting the "Madhopore jungle" which he never would have been, had he rightly comprehended that he was dealing not with *one*, but with *two* groups of alluvial beds unconformable with each other. The older of these groups may be either $\frac{\text{marine}}{\text{estuary}}, \frac{\text{fluviatile}}{\text{lacustrine}}$, or of a mixed and alternating character, but the newer group is essentially fluvio-lacustrine, and directly produced by the existing river, albeit at one time, under surface conditions widely different from those now existing; the former of these groups I shall speak of as the older alluvium; the latter, as the "newer" or "Gangetic" or "Irawadi" alluvium, as the case may be. One essential distinction between these two groups, apart from mere stratigraphical differences, is, that whilst no very considerable thickness of the newer group can anywhere have been deposited, without a corresponding subsidence below of the area so raised at top, a very large accumulation of the older or estuary beds may have taken place, during an elevation of the area covered by them.

Under one of three conditions, every river discharges its waters into the sea, namely, within an area of either subsidence, quiescence, or elevation, and how largely, not only the character of the deposits of a large river are influenced by the prevailing conditions at the time of their formation, but the physical peculiarities no less of the delta itself, I shall endeavour to illustrate by the Irawadi, and the contrast which its delta presents to that of its sister stream, the Ganges—as these two rivers, the Ganges and Irawadi, happily furnish us with examples of rivers subjected to respectively the first and last named conditions.

In the Ganges valley the development of the *newer* or *Gangetic* alluvium properly so called (or as I would propose to restrict the term) is very considerable, and its relation and junction with the older deposits usually well defined. In the upper part of the valley it is more or less restricted to the immediate neighbourhood of the river and to the narrow limits within which the river alters its channel, but it at once spreads out on either bank over a vastly broader area than before, so soon as we descend below the confluence, on their respective banks, of the Gandak and Són; the newer deposit assuming, east of those rivers, much of the importance, as far as area goes, which the older group claimed to the west. On the north of the Ganges, in the meridian of Purneah, the newer group is thirty miles broad, which corroborates a native tradition, that that city once stood on the Ganges.*

Eastward from Purneah, in the direction of Rajshaie and Pubna, the newer deposits spread over a wide tract of low-lying country, the older clay being, however, often but a few feet below the surface, and exposed in the beds of tanks or other artificial sections. Where this clay arises from beneath the newer group, we often find it (if not usually) presenting a clearly defined boundary, giving rise to an elevated tract of country, which offers a complete contrast to the low-lying inundated land occupied by the newer alluvium—as an instance of which, I may quote the narrow strip of clay country which runs down through the newer group, and strikes the Ganges above the station of Rampore Beauliah, near Burgatchee. South of the Ganges, all round the Rajmahal hills, the boundary of the two groups is more intricate, and in some of the railway embankments a curious contrast is afforded by the difference in color of the clays belonging to different groups of which the embankment is composed, the earth at one end derived from a patch of old kunker clay being a bright reddish yellow, whilst at the other, it assumes a pitchy hue, from being taken from a bed of the newer deposit, dark-colored from the accident of its forming part of the dried up bed of a

* It is possible that this estimate may require to be enlarged, but after examining the ground, I concluded that the sandy beds north of Purneah pertained to the older rather than the newer group. Though near Purneah very flat and low, they rise and undulate considerably as we approach the hills, and include pebbles gradually increasing in size as we go north (or towards the hills) The gradient of the ground, too, after passing Purneah, is *at once doubled*, going north, that of the thirty miles between Purneah and the Ganges being uniform, so that I think there are substantial grounds for holding the view I have given The junction is, it is true, confessedly obscure, but this is the result of the sandy nature of the surface beds of the older group, which readily commingle and fuse, so to speak, with the newer deposits, the important fact of the gradient doubling along this line not being cognizable to the eye, but where the kunker clay of the older group is juxtaposed to the sands and silts of the newer alluvium the case is different and little ambiguity results.

marsh close under the hills (trap) in which spots the soil often bears no inconsiderable resemblance to the "Regur"* or dark "cotton soil" so extensively spread over Central and Western India.

If we follow the river by its most direct course to the sea down the Bhagirathi we see the last of the older deposit or "kunker" clay in the steep bluff of Rangamatia ("stained earth") over 100 miles as the crow flies above Calcutta.

Below this to the sea all is Gangetic alluvium, which at Fort William, as revealed to us by the boring operations for an artesian well, is about 70 feet in thickness, resting on the denuded surface of the kunker clay, which is clearly indicated by the "rolled kunker pebbles" strewn over it, and intersected at that depth by the bore. To consider, however, the older deposit, merely in its aspect as regards the Gangetic basin, excavated in it, is to neglect a great and important parz of its history, that is, the entire period during which the great thickness of beds under Fort William, revealed by boring, of which it constitutes the highest member, were being deposited. It is here we require to bear in mind the difference I have insisted on, between the Gangetic group proper and this older group, for there appear to me to be no such cogent reasons why we should consider these beds as "Gangetic" deposits involving thereby a depression of several hundred feet, when it seems a simpler solution equally supported by the facts of the case to regard them as estuary deposits accumulated during an upward movement of the land. The fragmentary condition of the matters brought up by the boring rod prevents any great weight attaching to the mere presence of lacustrine shells and carbonaceous matters at a great depth, as the enormous quantity of wood, vegetable trash and lacustrine shells, swept out to sea, from a tropical shore and forming in places matted rafts, must be quite adequate to leaving a lasting record in the marine strata formed in times past, no less than in those now forming in the Bay. It will hardly be contested that at no very remote period the sea bathed the southern slopes of the Himalayas and stretched from the Bay of Bengal to the Persian Gulf, and to this period during a rise of the land, and long prior to the very existence of the present Gangetic valley or drainage system, would I refer these deep-seated beds, one of the highest of which is the "kunker" clay which it has been the custom hitherto to regard as a Gangetic deposit. It may be so; but I have always held it to be marine on grounds quite independent of those suggested by the Fort William bore.

I do not, however, wish to affirm that this kunker clay which in *lower Bengal* I regard as $\frac{\text{marine}}{\text{estuary}}$ may not elsewhere prove to exhibit fluviatile characteristics, since in the upper part of the Ganges valley, say above Chunar, beds intimately connected with it, certainly afford fluviatile indications, and such variability is to be looked for in a deposit accumulated under such conditions as I have surmised; for supposing an equable elevation to take place over the whole area, still the accumulation of the coarser beds near the centres of supply of sedimentary matter, will be more rapid than that of the more remote, and they will consequently begin first to exhibit marks of fluviatile action as the sea or estuary shoals, whilst no such indications will be afforded by the others deposited in deeper water, and this appears to me a natural explanation of the fact of fluviatile beds occurring in the central and upper portion of the Ganges valley, in intimate connexion with the kunkery clay which itself nowhere exhibits any similar indications.

The reason, apart from any other considerations, which has mainly induced me to regard the old kunker clay, of lower Bengal at least, as a $\frac{\text{marine}}{\text{estuary}}$ deposit, is finding it high up on the flanks of Patarghatta hill, which rises somewhat abruptly from the alluvial plains close to the river, some few miles above Rajmahal. At the time of my visit, the clay was being worked in this position for lime, the kilns being placed near the foot of the hill for the convenience of "tipping" the "kunker" clay down to them. The occurrence of the clay at this

* An opinion I once expressed regarding the probable derivation of the "*Regur*" from the destruction of decaying trap rocks, or some crystalline rocks of similar composition, received curious confirmation during my examination of Eastern Prome. I there heard repeatedly mentioned a certain hill of "black earth" which the Burmese [illegible] Nothing like "Regur" had ever occurred to [illegible] and clays, which did not seem [illegible] found not one only, but three isolated patches, or three separate hill tops of black earth, in every respect a veritable Regur, being the decomposed surface soil of what I at first regarded as a trap cap to the hill, but which the last examined locality convinced me was a bedded trap ash, subordinate to the beds including it, and which happened to form the summit of the three hills capped by the "black earth" in question.

high level far above that attained by the rest of the bed in the neighbourhood can only be accounted for by one of three suppositions, either that it is a capping of clay carried up *en masse* by the hill whilst being protruded up through the alluvial group surrounding it, a supposition too unsupported by evidence to merit farther examination; or that it represents a remnant of a once continuous bed of like character, which once continuously stretched across and occupied to a corresponding height, the country now forming the broad and low lying valley of the Ganges, to which also the like objection applies as to the last; or lastly it may have been originally deposited where we now see it on the hill side cotemporaneously with the rest of the bed, occupying the plains, when Patarghatta hill constituted a rock, submerged beneath the waters of that sea, which I have previously alluded to as at no distant period occupying the plains of Bengal and upper India.

Much stress should not perhaps be laid on the negative evidence of an entire absence of fossils in this clay, but had it been formed by annual increments during Gangetic floods, it is not easy to understand how in such a homogeneous clay, and one so well adapted to preserve any mulluscous remains deposited in it, no shells are found, either such as occur so abundantly in river rejectamenta; or *Uniones*, for which it must have formed in places a congenial habitat.

In the Nerbudda valley a very similar clay occurs though at a *higher level above the sea*, and though shells are not common in it, yet such shells do occur in places, as are usually swept down into inundated tracts by river floods at present, as *Bulimus pullus*, Gray, *Helix fallaciosa*, Fer. &c., as well as fine specimens of *Uniones* with valves united as in life, of species still living in the district (*U. Indicus*, Sow., and a fine variety of *U. cœruleus*, Lea.)

The above are my grounds for inclining to the belief in the $\frac{\text{marine}}{\text{estuary}}$ origin of the older alluvial clay, in lower Bengal at least, and I will close my remarks on it by briefly describing its character and appearance. Where best seen, in some steep section on the bank of the Ganges, it presents the appearance of a stiff homogeneous clay, of a mottled yellowish or pale buffish hue reddening much by exposure to the atmosphere. It contains a small amount of fine sand, the presence of which in the fields and watercourses of the newer group is an unfailing indication of an approach to the boundary of the older. Dispersed through it also are numerous small ferruginous concretions like shots, but no foreign body either in the shape of pebbles or organic remains*, have to my knowledge been found in it. In some parts, as in the colliery districts about Raniguuj, where older groups of rocks cut out the alluvial deposits, gravelly beds surcharged with pisolitic oxide of iron, varying from a ferruginous gravel (in its consolidated shape termed laterite) to a bed sufficiently pure and unmixed to constitute a workable ore, occur stratigraphically subordinate to this alluvial clay, but they are mere local developments, varying in character, and influenced most probably by the nature of the rocks constituting the neighbouring country. With the exception of these gravelly, ferruginous and lateritic beds, which locally constitute a sort of bottom or junction bed of this clay, we have no knowledge of what it rests on save the rather meagre information to be gathered from the Fort William bore, neither do we know with certainty its total thickness† or if any beds superior to it in position have ever covered it, except, should my view of their relations be the correct one, the sandy beds which in Purneah and the adjoining Zillahs seem to overlie, or perhaps in part replace it; which ignorance arises from the very uniform elevation over its entire area of so thick and homogeneous a bed, and the general absence of artificial sections deep enough to pierce this.

Disseminated throughout this clay occurs the well known kunker or "gooting", occasionally in well defined nodules but more commonly in irregular stringy courses, and often so intimately commingled with the argillaceous portion of the bed, that the clay is dug in bulk for the kilns. Where this bed forms the surface of the country the more argillaceous portions are washed out, leaving the kunker strings, sheets and nodules projecting, or forming on the surface a sparse crust of "gooting" pebbles, and this is more observable in the upper portion of the valley than in lower Bengal, where the clay seems less rich in lime than to the north-westward.‡

* Bovine bones were found in a well near Patna, at 60 feet. T. OLDHAM.

† Its thickness cannot be regarded as under 60 feet.

‡ Sir Charles Lyell, speaking of the unchanged character of this clay (Principles. Vol. I, 429.) 1,000 miles *north* of Calcutta, doubtless intends the *north-west*, &c., *above* Calcutta following the course of the river.

I cannot here enter at length on the relation of either this clay with that (the identity of which I presume) of the Jumna valley, which has yielded the as yet undescribed "Jumna fossils" (mammalian) or with the analogous fresh water deposit of the Nerbudda valley, so rich in mammalian remains, but will content myself with remarking that the difference of level between these two deposits is such, that the deposition of the one in a series of morasses fed by a sluggish river (which seems to answer the indications of the Nerbudda clay), might have gone on simultaneously with the accumulation in a shallow sea of the other of which the Rewah plateau in part formed the southern shore.

Having dwelt at some length on the older alluvium of Bengal, I will now pass to the newer deposits, or Gangetic alluvium properly so called, which will require a much briefer notice than the last. The newer or Gangetic alluvium comprises a very varied series of beds, directly precipitated from the waters of the Ganges, or its tributaries. It is at once an extensive and important group deposited within the trough excavated by the Ganges in the older clay, or filling up such low lying tracts as receive the flood waters of the Ganges during its annual inundations. It comprises some of the most fertile land in Bengal as in Tirhoot, which is styled the "garden of India" where it is largely developed, as also in Purneah, Rajshaie, Maldah, and in all the Zillahs which intervene between them and the sea. Its mineral character is very varied from a dark silty brown to a dazzling white sand, and in the sections of the deposit exposed in the banks of the larger rivers we see nothing like the homogeneity of the older clay, but a succession of beds of different thickness and various composition, as is the normal condition of an unmixed fluviatile deposit.

It loses something perhaps of its characteristic aspect, within the tideway where the presence of tidal waters, and tidal mud, makes itself felt, but with the exception of the belt of country within the limits of the present tideway, it is essentially a typical river-deposit. About Calcutta however, though its aspect is somewhat altered by the influence of the tides, it must still be ranked as a $\frac{\text{fluviatile}}{\text{lacustrine}}$ deposit, as it contains several beds of peat clearly a marsh accumulation and sufficient to stamp its character and origin. I am aware that at Calcutta, and doubtless elsewhere within the tidal zone, oyster shells have been found and other relics pointing to marine conditions, as soondrie wood *in site of growth*, a tree which only flourishes on land overflowed by the sea, but we must presume that this deposit during the whole period of its growth, of over 60 feet at Calcutta must have been every where traversed by deep tidal creeks on the banks of which the soondrie tree flourished and in whose quiet depths oysters and other marine organisms lived, and the bore at Fort William leaves small doubt that since the epoch when the underlying older clay had been sufficiently elevated to form a tract capable of supporting vegetation, a contrary movement of depression has been going on at a rate which permits the accession of Gangetic sediment at top adequately to counterbalance the subsidence simultaneously going on below.

Let us now compare with the alluvial groups in the Ganges valley as sketched above, the similar deposits which occur in the valley of the Irawadi, prefacing the subject with a few remarks on the physical character of the country which presents some features peculiar to it, resulting from the geological structure of the delta.

The delta of the Irawadi is embraced between the Myit-ma-kha Choung, on the east, which, under the name of the Rangoon river, falls into the sea below that town; and the Bassein river on the west, which is given off as a small stream from the main river near the village of Thambyadeing, and enters the sea near Negrais Island; Elephant and Poorian Points which respectively mark the entrances of these rivers being 137 miles apart as the crow flies. The Bassein river forms naturally the most westerly arm of the Irawadi, though at its origin its size is inconsiderable; but the Myit-ma-kha Choung rises near the town of Prome, and running parallel with that stream first receives the surplus waters of the Irawadi, when flooded by channels which anastomose with it, opposite and below the village of Pouktein, 45 miles above the origin of the Bassein river; Menghee, situated between these two points, may therefore be fairly taken in our calculations as the head or apex of the Irawadi delta; on which supposition, as the distance from Menghee and Elephant and Poorian Points is respectively 129 and 176 miles, the area of the entire delta is about 12,000 square miles. By an independent calculation, I estimate the area of alluvial deposits within the delta at 11,000 square miles, as some groups older than alluvial occur within the delta, but no exact calculation can be made from the want of any, save an arbitrary boundary, of them to the eastward, where they creep round along the Gulf of Martaban, and blend with the deposits of the Sittang valley. Proportioned thus regularly as the Irawadi delta is, as regards contour, with its three sides respectively 129, 137, and 176 miles long, it may not at once seem obvious how Mr. W. Blanford, in speaking of it, called it "a less perfect delta" than that of the Ganges, I shall, however, endeavour to show wherein it differs essentially from such delta of the Ganges, not in form, but in respect to its composition and history.

The most striking feature connected with it, is not its mere flatness, which is naturally to be looked for in such an area, but its extremely low level. No definite assertion can of course be made, but I think I am well within the mark when I say that 2,000 square miles of this tract must be below the level of a high spring tide and fully as much more not raised more than a foot or so higher. Passing through any of the creeks when a spring tide is at its height, the water is seen pouring inland up every channel and watercourse, and diffusing itself over both fields and uncultivated ground, and the conviction produced is, that a permanent submergence of a considerable tract within the delta would be the result of the water being maintained at the full height of the springs for any considerable period; as it is, however, in the course of an hour or so, the tide falls and the flooded land relieves itself through the usual channels. This extremely flat character of the country may be surmised from a mere inspection of the map, from the numerous lakes or "Engs" as they are called, scattered all over lower Pegu, and from the anastomosing and often tortuous character of even the largest river channels.

For instance, a little below the important town of Nyoung-don the Irawadi divides into two nearly equal branches, each possessing the dimensions of a first class river, one branch flowing south and discharging itself by the Dalla mouth, whilst the more westerly branch enters the sea by the Irawadi mouth. Twenty-five miles as the crow flies below the point of bifurcation of the two streams, is the small village of Tan-ta-lop Kyoung, to which I shall hereafter refer, but following the bank of the former branch or Dalla river on which it is situated, the distance is raised to 45 miles or nearly double. From the same point of bifurcation, at the same distance as the crow flies of 25 miles, on the other branch or Irawadi river is the important town of Shuay-loung; the distance to which, following the river bank, is 42 miles nearly.

Still more tortuous is the Daga river in some parts, which constitutes the most westerly channel of the Irawadi within the delta, and which, though a far narrower river than either of those above mentioned, maintains a deep and permanent channel. From the village of Shekhabyeng to the point of discharge of the Daga lake, is, as the crow flies, 18 miles, but measured along the river bank the distance actually exceeds 55 miles, which will give a notion of the extremely level character of the country it traverses—which character is not confined to the delta merely, but marks more or less all lower Pegu, save in the vicinity of the hills.

Such being the surface, character, and conditions of the delta we might not unreasonably be led to expect within it a great development of the newer or Irawadi alluvium, but so far from this being the case, the country is almost entirely composed of the older group to the almost total supersession of the newer. This will be most forcibly realised from the statement that the entire area (excluding the actual river channel) occupied by the newer or Irawadi alluvium in the valley, amounts to but 200 square miles, of which 60 miles is made up of scattered patches adjoining the river, all lying above the bifurcation of the Dalla and (Pantanau) Irawadi rivers, whilst the remaining 140 square miles constitute an isolated tract or oasis of recent deposits, below Pantanau, which seem to occupy an original trough or depression in the surface of the older group. From this it will be apparent, that with great similarity of surface conditions between the deltas of the Ganges and Irawadi, great dissimilarity exists touching their geological constitution, the newer group of alluvial deposits so largely developed in the former being, so to speak, absent in the latter. The cause of this, briefly stated, is the fact that the delta of the Irawadi at this present time is in precisely the condition of the delta of the Ganges at the time when the first layers of Gangetic alluvium, 70 feet below the present surface at Calcutta, were being deposited, and when through the single or joint action of deposition and elevation, the older marine group had become sufficiently raised to admit the deposition of beds stamped with a fluviatile and terrestrial character, and even the accumulation of such matters as peat, to permit of which the newly raised land must have been at least as high above the sea, as the better raised portions of the Irawadi delta; since then a steady downward movement of the Gangetic delta has permitted the enormous accumulations of newer or Gangetic alluvium which covers so large an area in Bengal, whilst the future can alone disclose if any similar movement of depression will ever permit a corresponding accumulation of Irawadi alluvium in the delta in Pegu. That no such movement has taken place hitherto is clear from the absence of the newer deposits which would have originated in consequence of it, and moreover the proofs of a general elevation are, as I shall show, sufficiently clear and undeniable.

Let us now consider how far the surface conditions which obtain in lower Pegu correspond with the supposition above advocated, of a somewhat recent elevation of the country from the sea (including, in the term elevation, the accessory agent of silting up), which, be the area rising or sinking, is always going on in so shallow and protected an estuary as the head of the Gulf of Martaban. The appearance of the bed of such an estuary as that in question, would, on its first elevation above the sea, be that of a dead level regarded as a whole—merely furrowed here and there by such channels as the drainage action of the retreating waters would inevitably carve out in a plain of soft easily-removable matter. An exception to this dead level character might here and there exist either in the shape of banks of sand or other accumulations produced by currents; or depressions in the general surface produced either by the locally increased set of currents preventing the deposition of sediment or their absence altogether checking the delivery over particular localities of even the finer sedimentary particles. If we endeavour to follow the history of these suppositious depressions subsequent to their permanent elevation, and conversion into dry land, we shall thereby obtain a clue to the origin of the most prominent features at present of the Irawadi delta, *viz.*, the presence throughout it of innumerable small "engs" or lakes, the occurrence of some of different character, such as the Daga lake, and the existence of the curious isolated tract of newer alluvium, lying south of Pantanau. It is clear that in such a case as that supposed above, one of three results must happen to any depressions which the newly elevated surface may present. If the depressions are of small extent and of a shallow character, they will be converted into small lakes or "engs" in the rainy season, and be more or less dried up and converted into grassy plains, such as are commonly seen in Pegu, with a swampy navel perhaps in the centre, during the dry season. If the depression is of larger dimensions, or receives a larger supply of water than evaporation can dispose of. it drains itself naturally into the nearest or most accessible drainage channel in the country, and this appears to be the case of the Daga lake.

Should again the depression be extensive, and, as its existence might be held to render probable, it should be intersected or connected with one of the main drainage channels of the country, it will in such a case be silted up by repeated accessions of flood waters charged with sediment, and this appears to be the origin and history of the oasis-like tract of newer alluvium near Pantanau, which has all the aspect of being an extensive trough-like depression in the original surface of the land, lying in the course of two of the largest branches of the Irawadi, and in consequence speedily silted up to the level of the surrounding country by its waters.

The difference between this case and the last is one it may be said of degree, but an aboriginal difference of level, though merely one of degree, produces exactly opposite results. A moderate depression, such as the Daga lake (even *cæteris paribus* and in this case the ground surrounding it is the higher), would, during the floods, as a rule, discharge into the nearest river, whilst a greater depression, like the Pantanau trough, would, during floods, never discharge into the river, but always itself be the recipient (*till* silted up) of the waters of the flooded stream.

The Daga lake may be now briefly noticed as it forms a curious feature in the district I am describing. The Daga lake is an annular piece of water situated on the west bank of the Daga river, 25 miles north-west from Pantanau. Its shape is irregularly oval, 2½ miles long, and varying from half a mile to a mile in width. It discharges its surplus waters into the Daga river by a short channel of about ¾ of a mile in length, but from always remaining full is probably as deep as the channel of the Daga river itself. It is economically valuable as a fish preserve, and an account of the annual drawing of the lake is given by the late M. O'Riley in the Journal of the Asiatic Society, Bengal. M. O'Riley speculates on the mode in which it has been formed, but as he refers it to some vague intestine movement of the neighbouring strata, I am unable to agree with his conclusions. Did such a piece of water occur in proximity to a large river channel in lower Bengal, it would at once, and probably correctly, be referred to a deserted bend or knuckle of the river, and such was my impression in the present case before examining the ground. I anticipated finding a considerable area of newer deposit of river silt marking the former extension of the Daga river, but nothing of the sort exists, the permanent banks of the river displaying the ordinary section of older clay, and the island occupying the centre of the lake being formed of the older clay likewise. No other conclusion therefore remains but to regard it as an annular depression which originally existed on the surface of the older alluvium on its first elevation from the sea, deepened, enlarged, and wrought to its present shape by atmospheric agency. Besides atmospheric agency, which seems scarcely equal of itself to produce such a piece of water (else would they be more common), even when aided by the original contour of the ground, I should suspect some peculiarity in the soil constituting the bed of the lake. The older clay of the delta is, it is true, remarkably homogeneous as a whole, but this is not inconsistent with the occurrence in it of thin bands of a different composition. An instance in point occurs to me in the Purneah district of Bengal, where a thin band-like portion of the older clay usually so tenacious assumes almost the character of a quicksand by mixture with water, forming a sludgy compound, easily removable by the action of either springs or a stream. Some such band may very possibly occur in the older clay of Pegu, and if it occurred at about the mean height of the water on the Daga river, or lower, it would go far to explain, by the facility with which it would pulp down and flow away, the annular shape of the lake, which of course, however obscure the cause, is not purely fortuitous. In this view the original depression of the ground may have been trifling, sufficient perhaps only to give direction to the scouring action subsequently set up.*

A noteworthy point connected with the physical character of the delta of the Irawadi is the more persistent character of the river channels in it. Towards the upper part of the delta and above its proper limits, the Irawadi channel is never more than five miles broad between its ***permanent banks*** as they may be termed, that is the opposite margins of that trough scooped by the river in the older alluvium, and of which a considerable portion is usually refilled with river deposits. Within the delta proper towards its mouth, the present river channels are more permanent, and evince little tendency to deviate from their established channel. Even such rivers as the Daga, which wind in the most circuitous fashion in a level country, exhibit no such tendency, affording in this respect a striking contrast to the habit of rivers in the Gangetic delta. The Kosi for example oscillates from east to west (its present direction) over an area of probably not less than 30 miles, and a town which stood on the west bank of its main channel at the period of my visiting it first, stood on its east bank the following year, through the re-opening and scouring out of a disused channel in its westerly course. The station of Rampore Beauleah is in like manner suffering from the encroachment of the river, and so long back as 1855, steamers anchored where houses once stood. Nothing too is a commoner process in the Gangetic delta than the obliteration of a river channel, and its conversion into a fertile plain, a change not unfrequently effected in the course of a few years. Now, save within the narrowest limits, nothing of this sort takes place in the Irawadi delta, and this is I think attributable to the different constitution of its delta, and the absence of any extended development of the newer group, within which the incessant changes in the Gangetic rivers take place, or in other words owing to the greater and more equable resistance to erosion of an homogeneous clay like the older deposit, than what is afforded by banks composed of newer silty deposits, and such fluviatile accumulations. Local peculiarities may in some spots cause a wasting of the older clay, as at the important town of Nioungdon, where a great extent of sand flats and shallows have resulted from the excessive denudation suffered by the older clay, giving rise to a sprawling channel very different from the deep permanent channel usually seen in the delta, but the cause is obviously a local one, the clay here resting on an incoherent pebbly sand, which melts away and allows the overlying bed to topple into the river, and the process which is rather exceptional in Pegu in the older group produces the same result as in Bengal, where it is an universal operation in the newer.

* Mr. O'Riley himself subsequently to the publication of the paper referred to, changed his view of the formation of this "lake"; and believed, as certainly appears the much more rational and simple mode of accounting for its formation, that it is simply an unfilled-in bend, or as Mr. Theobald says "knuckle" of the river. Everything seems to be in harmony with this view, and Dr. Day, in his recent Fishery enquiries in Burmah, was also satisfied that this was the true explanation of the facts. T. OLDHAM.

It may perhaps seem strange, that, with so eminently level and low lying a tract of country as I have described above, over which flood waters are repeatedly effused, no considerable deposit of river sediment has taken place. The objection is to some extent plausible, but I shall now hazard a few considerations which greatly diminish its force. In the first place I would beg attention to the fact previously stated by me, which lies at the root of the entire question, and that is, that the Irawadi delta is at this present time in the precise condition which the Gangetic delta presented, when, in the latitude of Calcutta, the older alluvium, now about 65 or 70 feet below the surface and considerably therefore below the sea level, was nearly the height of the present surface and beginning to receive those accretions of fluviatile and lacustrine deposits which now constitute the 70 feet of newer deposits whereon Calcutta stands, as before shown. This is precisely the condition of the Irawadi delta, and a downward movement, with a corresponding development of fluviatile beds, is all that is required to create a strict parallelism between the two deltas. For *corresponding* development I might perhaps rather say *consequent* development, as the deposition of any thickness of these fluviatile beds is proportionate to the subsidence of the area occupied by them, hence their absence in any force, over any elevated area occupied by the older group. At the same time I do not wish to be understood as denying that, the flood waters which cross the country leave no deposit, but only as insisting on the superficial and I may say insignificant development of this group in Pegu, from the reasons above given. When the entire country is composed of the older clay a thickness here and there of a few feet scattered over the surface and that after a very sparing fashion, scarcely deserves comparison with the extensive and thick deposits of Gangetic alluvium. In the river banks a couple of feet at most, and this I consider an over estimate, of surface soil is seen, the entire bank being composed of the old homogeneous clay. Farther removed from the main channel the deposition of river silt is even more trifling on two accounts; firstly from the more copious deposit of silt on the river bank, through the diminished velocity of the expanding overflowing waters, and secondly from a cause not usually sufficiently borne in mind. It may seem paradoxical, but the low level and small inclination of the ground is a serious obstacle to its becoming silted as I shall show. When a cross country "spill" takes place and flood waters charged with sediment traverse a low country, deposition of course takes place, as when the floods of the Sóne abandoning their proper channel pour irregularly across the plains of Behar, and in place of falling into the Ganges above Patna, effect an irregular discharge for themselves below it. Very different, however, is the case of a river running through so flat a country as the Irawadi delta, and possessing a rain-fall such as Pegu does.

The first showers of rain fill the numerous "engs" or depressions scattered over the country, and these gradually enlarging, submerge the country before the turbid floods of the river have risen to a similar height. In default of any effective drainage, the ground adjoining the rivers being higher than the flooded interior, the ordinary rain-fall of the district is usually adequate to produce this effect, but the low land skirting the hills, receives in addition considerable, though irregular supplies through streams which pouring out from the hills diffuse themselves over the country, and lose themselves in the plains. A vast quantity of sand is swept down and forms a sort of encroaching talus margining the plains, but the somewhat depurated water mixed with the pure rain water of the plains, together forms a body of water very limpid and free from sediment, though eventually often tinged with brown from decaying vegetable matter. The turbid waters of the Irawadi now rising, top their banks, but their course is soon arrested by the limpid water of the plains and may often be traced holding on their course without mingling with the other by the contrast in colour the two bodies of water present, and this balance of power of course tends powerfully to reduce the deposition of silt to a minimum over these inundated plains and restrict it to the immediate neighbourhood of the larger streams.

In appearance the older clay of the Irawadi valley much resembles the older clay of Bengal, but it differs from it in being very deficient in lime, and rarely containing, and then but sparingly, these calcareous concretions or kunkur which give a distinctive character to the deposit in Bengal. It is a very homogeneous deposit throughout, but a thin dark band in it shows that it dips seaward, or to the south, at a greater angle than the surface of the land, which proves that the process of elevation has been greater inland than towards the gulf of Martaban. This is quite in accordance with evidence of an increased elevatory movement as we proceed up the coast, northward. Towards Cape Negrais no prominent signs of elevation present themselves, but as we approach Gwa we find gradually proofs of a somewhat recent rise of the coast, in the shape of coral banks raised above the present limits of its growth and in the presence, a few feet below the surface in the plains now removed from the shore, of shelly sand and shells of species living on the coast. Above Myanoung this dark band is cognizable high above the dry season level of the river, but within the tideway it occurs about midwater mark or lower, and is in many places dug out for pottery, being highly plastic and adapted for such purposes.

Towards the top of the tideway the older alluvium or yellowish clay rests on a pebbly sand, which is visible at Nioungdon, where it is rather better $\frac{\text{developed}}{\text{exposed}}$ than usual. This sandy bed is doubtless the homologue of those extensive beds of gravel which towards the frontier, underlie the older clay. Opposite the village of Monyo, near Nioungwaing, gold washings are carried on in the bed of the river on a shingly bank which belongs to these coarse gravels, and these gravels are probably the source of the gold which in many spots is occasionally washed for in the Irawadi, though the returns are too poor to attract continuous labor. This older clay is not confined to the valley of the Irawadi, but occurs likewise in that of the Sittang—and, which is rather difficult to account for on any other hypothesis than that which I have adopted, of its estuary origin, in the upper parts of the river valleys on the side of the Arakan Coast. In some of these valleys it is seen deeply cut through by the river channels, and very often appearing little more than a remnant of a once extended deposit. In such positions it is often masked and covered over by an enormous accumulation of rocky detritus swept down over it by rains from the adjoining precipitous hills. This is not a situation favorable to the accumulation of a homogeneous clay, through long-continued fluviatile action, but rather points to a period when its equable diffusion took place within the sea. The coarse gravels which underlie the clay towards the upper portion of the delta and towards the frontier are clearly of marine origin, as no other agency is adequate to formations of such coarse shingle as that in question. Opposite Prome this gravel rises to upwards of 60 feet above the flood level of the Irawadi and is fully 30 feet thick reposing on miocene strata. The older clay is not seen here being apparently denuded, but at Thaietmio the relation of the two beds is well seen. In the neighbourhood of Thaietmio, this gravel contains numerous well worn and rounded pieces of fossil wood, six inches in length and occasionally logs two feet and upwards in length. These logs have, of course, not travelled far, and are derived from the miocene sands containing silicified wood in the neighbourhood. Their presence, however, with other hard rocks, in well-rounded lumps is clearly indicative of their origin in situ as a marine shingle bank. Equally conclusive is the thick deposit of coarse shingle comprising well-rounded boulders, many of six and nine inches in length of the hardest schists, exposed in the river bank under the old Fort of Miade above Thaietmio on the opposite bank, and I can draw no other conclusion from these deposits, than that, anterior to the deposition of the older clay, they formed shingle banks in a shallow sea or estuary in which their hard silicious ingredients were rolled about and polished down as we find them in the gravel. Having in a previous notice described the beds whence the fossil wood has been derived I need not here allude to them, but I think I may confidently assume that marine and not atmospheric agency was the force employed in the removal (in part at least) of these fossil-wood beds, and in reducing the silicified trunks so abundantly contained in them into the innumerable smoothed blocks, boulders and pebbles of fossil wood so characteristic of the Irawadi gravels.

I will conclude my remarks on the Irawadi alluvium by pointing out the effect to man, and the extent to which his industry is affected by what might seem merely a trivial or theoretical difference between the delta of the Irawadi and Ganges. I have already shewn that within the Irawadi delta, but 200 square miles occur of the newer or Irawadi alluvium proper, but without affecting to estimate the area occupied by the corresponding Gangetic alluvium it may be taken as far more than two hundred times that amount. Now, it is on this newer alluvium that the finest indigo is grown, and indigo and $\frac{\text{silk}}{\text{mulberry}}$ may be said to be the two main staples of the zillahs in Bengal occupied by the newer deposits. Not only this, but the newer alluvium will produce any crop required of it, either rice, sugar, opium, oil seeds, &c., and hence from the occurrence of these newer deposits over so large an area in Bengal, that province has acquired the name for fertility it possesses. In the Irawadi valley, in place of this fertile deposit, we have the older alluvial clay, which, though where it forms an undulating country, or beyond the limits of the delta, and on the upper part alike of Pegu or Bengal, is capable of producing valuable crops of various descriptions, yet where it occupies such low land as the delta, is fit to sustain nothing so well as rice crops; and hence the inability of the delta of the Irawadi to compare in richness with that of the Ganges, or to furnish in like abundance the various products, which a seemingly trivial difference in geological composition enables her more favored sister the Ganges to produce.

Rangoon, 15th June 1869.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1872. [February.

Annual Report of the Geological Survey of India, and of the Geological Museum, Calcutta, for the year 1871.

The close of the year calls for the usual annual summary of proceedings of the Geological Survey.

As regards the staff available during the twelve-months from the 1st of January to the 31st December 1871, we have been rather more fortunate during the past year than on other occasions. During a portion of that time, all the members of the Survey establishment were at work at the same time—a rare occurrence. Shortly after the year opened, Mr. Jos. W. Alexander was appointed an assistant in the room of Mr. Ormsby, whose death it was my duty to report in 1870. Mr. Alexander was engaged in office work for some months, and gave high promise of efficiency. After a few months, he was, however, nominated by the Hon'ble the Lieutenant-Governor of Bengal to the charge of the Maharajah of Durbungah and of his brother (minors). His place was fortunately supplied without much delay by the appointment of Mr. James Willson, A. B., whose university course had been marked by the highest honours, and who had for some time been engaged successfully as Professor of Mathematics in this country. He had given special attention to the study of Physics, Geology and Mineralogy, and had obtained honors in these subjects at his final examination in Trinity College, Dublin. He has been actively engaged since his nomination in October.

These repeated changes, as frequently noticed, give rise to delay, complications and difficulties, which very seriously impede the progress of the survey. It has been recommended as the best means of preventing, so far as practicable, this injurious result, that two or three supernumerary assistants should be appointed who would become absorbed into the general staff as vacancies occurred, and who would meanwhile have acquired a sufficient intimacy with local geology, and with the modes of enquiry to enable them to be at once effective and useful. The working staff would thus be maintained at its proper strength and an equable progress would be secured. At present, every new assistant is comparatively useless for one whole working season, until he has become acquainted with what has been done, and can thus take his place with the others in extending this knowledge.

Mr. Medlicott, who, as stated in last report, had commenced the detailed examination of the country near Mohpani coal-field, and the Puchmurri hills, on the south of the Nerbudda valley, using for the purpose of recording his observations the maps of the Topographical Survey, just issued, was enabled to get over a considerable area. As noted on a former occasion, when this important district was first visited by the Geological Survey in 1856-57, no maps of it existed, and to give even an approximate idea of the structure, it was necessary to construct a sketch map as our work progressed. This, of course, had no pretensions to great accuracy, and it was therefore important to take advantage of the publication of the regular survey maps at the earliest date. Towards the close of the season, Mr. Medlicott, I regret to say, suffered from a very severe attack of fever which incapacitated him for work. Hoping that a little rest and change of air would restore him to health, he obtained three months' privilege leave and proceeded to England, but the attack proved so severe and continued that he was obliged to obtain an extension of leave on medical certificate. Finding himself quite well again, he has returned before his leave expired, and has taken up the continuation of his old work on which he is now engaged. It is hoped that he may have no return of the attack. He resumed work at the commencement of December.

Mr. W. T. Blanford, who had at the opening of the season proceeded to the Godavery river to report upon the various places where coal had been said to occur in the vicinity of the great works for the improvement of the Godavery at Dumagudium, very successfully completed the careful mapping of the coal-bearing rocks within the British territory, and carried the lines of boundary into the country of His Highness the Nizam on the opposite side of the river. Two sets of boring-rods had been sent out from England for this district, and these were placed under the immediate charge of Mr. J. Vanstavern, C. E., Executive Engineer at the Godavery works. Previously to the arrival of these tools, Mr. Vanstavern had been carrying out a series of short borings with some small tools at his disposal, but immediately on receipt of the others, he commenced a systematic examination of the entire area of coal rocks on the British side of the river, acting strictly in compliance with Mr. Blanford's suggestions. Mr. Heppel was also moved down from Chanda district, and for a short time superintended the actual borings. After his departure, and up to the present time, Mr. Vanstavern has with much skill, intelligence and system carried out the series of borings agreed upon, and there only remain now one or two still required to give a very complete insight into the structure of the area in question. It is unnecessary here to enter into details, as Mr. Blanford's results have been already published. Unfortunately there is little prospect here of any but a very limited supply of poor coal. The area of the rocks which occurs in British territory in this vicinity is very small, and the beds of coal which occur are most extremely irregular and thin. Mr. Blanford's estimate of 12,000 tons may be added to in consequence of more recent borings, but at best the supply is limited. And the larger portion of the coal must be sought for on the opposite bank of the river in the territories of His Highness the Nizam.

One of the first matters to which Mr. Blanford directed his attention on arrival at Dumagudium was to take advantage of the accurate local knowledge of the countries they inhabit, which is always possessed by the wilder tribes inhabiting the jungles and more inaccessible portions of the districts, by a well directed distribution of small fragments of coal over all the country, thus showing to the people actually what it was, for the discovery of which a liberal reward had been offered by the Government of the country. The success of this plan was not long after attested by the report to the local authority of the existence of thick beds of coal in the valley of a nullah not very far from Pakhall, in the vicinity of Warungul. There would seem to be here a thick bed of coal well exposed, said to be dipping at the high angle of 45°. The country around is all jungle, at present frequented by wild elephants, but it could be easily opened out. I have no doubt that other similar reports of coal will be brought in from time to time.

Mr. Blanford later in the season carried out a general mapping of the extent of the sandstone area in this part of the Nizam's dominions, and southward into Madras Presidency, where it stretches down to within about eight miles of Ellore. All these rocks as seen at surface appear to belong to the group which occurs over the true coal-bearing rocks. The country is very widely covered by jungle and poor forest, and is in many places quite inaccessible for close or detailed examination. But, so far as practicable, a knowledge of its structure will be obtained during the present year by Mr. King, who has been placed there for this purpose.

Mr. Blanford completed a long season in this very unhealthy country; but not, I regret to say, without suffering. He was very unwell afterwards in Calcutta, but was able to take the field in Sind at the beginning of the present season. On his way thither, he devoted some time to the examination of the neighbourhood of Bombay, where the Municipal Commissioner had sought the advice of a Geologist with reference to a proposed plan of conveying water to the city through tunnels in the solid rock, which it was supposed would prove much cheaper than the laying down of iron pipes.

Since Mr. Blanford's arrival in Sind, he has been deputed to accompany the Boundary Commission under Sir F. Goldsmid in its visit to Seistan, &c., a trip from which I confidently anticipate that much valuable information regarding a country almost entirely unknown will be derived. It is a duty also for which Mr. Blanford's wide acquaintance with Natural History in general as well as Geology peculiarly qualifies him. He has made most excellent use of the brief delay which occurred before starting, and has been able to visit many places of interest in the Persian Gulf and also on the Arabian Coast.

Mr. W. King, Deputy Superintendent for Madras, on his return from furlough, commenced his field examination from the Toongabudra river, and examined the country lying on either side of the Madras and Bombay railway up to the boundary of the great area of trap rocks which cover such an immense space in the Deccan. The main object, as stated before, was to carry out here an investigation of the several rocks which occur between this vast thickness of overlying trappean rocks above and the even more widely spread base of the underlying gneiss and other metamorphic rocks below. Joining on, therefore, to the south-west with the lines already fixed by Mr. Foote as noticed in last report, Mr. King advanced to the north-east, and was able to get over about 1,400 square miles of area up to Goolburga. Towards the latter part of the season Mr. King was attacked with fever, and other symptoms, and was driven into Bombay for medical advice. On getting better, he quickly returned to his work; but the season was then so far advanced that much further progress was impracticable.

The rocks met with were (1st) the crystalline metamorphics, consisting chiefly of granitoid gneiss, quartzo-felspathic in composition, with little foliation, where seen with a northerly strike and at low angles. This gneiss is much traversed by small granite veins (binary,) lying to a large extent in the lines of dip. Occasional bands of hornblendic gneiss also occur. The hilly and rugged parts are also frequently studded over with large bosses and tors. The surface is generally flat and covered up by black cotton soil and alluvial deposits.

Overlying the gneiss in the valley of the Bheema is a series of limestones, sub-metamorphic in texture and bearing a strong general resemblance to the Karnúl rocks. This may be provisionally called the Bheema group. It consists in descending order of—Red purple and chocolate coloured calcareous shales, flags and thin-bedded earthy-grey limestones; thicker bedded earthy and sub-crystalline limestones. There is locally a great lenticular patch of quartzitic, sandy and conglomeratic beds. There are also, of course, many local variations in the groups from the general character given above. The most remarkable of these is a series of brecciated beds, in which the materials composing the layers have been separated into numerous sharply angular pieces, and recemented by a material of precisely the same general character as the mass. These are exactly like similar beds described in the Karnúl and Kadapah formations. Generally, the lie of these Bheema beds is quite flat, or with a gentle dip to the north-west. The different groups noticed above do not appear to be unconformable, but the newer overlap the older to a considerable extent. This is the case also with the trappean beds which come over and rest upon the Bheema rocks. Where in contact, only slight alteration has been produced in the underlying beds by the overflow of the traps; purple shales become of a bright red colour, and weather with a soft velvety powdery surface, &c.

Of the traps themselves, there is only a very limited thickness near the boundary. The series is made up of several thin flows of various kinds, and of different degrees of compactness and hardness. The uppermost flow is generally decomposed into a form of lateritic rock.

Mr. King has at the commencement of the present working season carried on these boundaries a little further to the north-east, but was obliged to hurry on to take up the examination of the Godavery area to which Mr. Blanford was unable to return. In addition to this field work he has also supplied the Director of Revenue Settlements, Madras, with notes on the geology of the Cuddapah and Nellore districts.

Mr. Bruce Foote continued the examination of the similar rocks to the south-west joining on to the limits of last year's exploration. It was hoped that he would have been able to complete the country up to the western ghats, but the boundaries proved so much more intricate and complicated than was anticipated, that this was impracticable. Mr. Foote's close examination of the country was rewarded towards the end of the season by the very interesting and important discovery of the fossilized remains of a *Rhinoceros* in the regur or black cotton soil. These have since been worked out with great care by Mr. Foote, and will be hereafter described.

Mr. W. L. Willson has continued the examination of the southern portion of the Jhansi district, and of Lullutpur to the south, and the native states of Tehree, &c., to the east. Over all this country the same remarkable series of trappean dykes and quartz reefs, already noticed as occurring in the adjoining districts, can be seen, running up to the Par sandstone scarp south of Gwalior to the north-west, and to the very bases of the Vindhyan and Bijawur rocks in the south-east. In no case, however, do these dykes penetrate either of these formations. They occur, apparently more numerously than elsewhere, from a few miles north-east of Jhansi to the Vindhyan scarp on the south-east; their range being chiefly from north-20° west to north-west. There is a tendency to a more easterly strike, as you pass to the north-east towards the Dessaun river and Nowgong, while along the Dessaun a very few occur, which head north, or a little west of north. The dykes frequently divide and form loops. Many of them are of considerable size, and a few can be traced for many miles in nearly right lines. They are, whatever their actual age may be geologically, undoubtedly subsequent to the 'quartz reefs,' through which they are seen to pass, and portions of which they show imbedded in the mass of trappean matter along the edges of the dyke.

Some curious outliers of the infra-trappean limestone were noticed in the southern part of Lullutpur well out on the general flat composed of the crystalline rocks and covered by the ordinary Malwa and Deccan trap rocks; these are of the usual earthy and cherty light coloured calcareous rocks, in places worked for lime to whitewash the houses with. North of Jacklone the base of the series, as elsewhere in Saugor, is formed of pebbles of sandstone in which numerous fragments of chert and limestone occur. When the soft matrix is washed out the beds appear to consist only of these pebbles, occasionally some feet in thickness. Black soil occurs in all these localities over the kunkury clay, which forms beds of considerable thickness, 30 to 50 feet. Mr. Willson also notices a remarkable local development of black soil. "In very many places, when a large dyke is traceable through a valley, with ridges of gneissose rocks on either side, it frequently forms a marked lane of black clay up to the base rocks bounding it. And the dyke may often be traced across alluvial ground by this lane-shaped band of black clay, although no rock is visible." Another fact in the physical configuration of the country arises from the resistance to decomposition of these trap dykes, which, therefore, very frequently occur along the top of the minor watersheds, where also most of the villages are placed.

During the present season, Mr. Willson continues this examination to the east, completing the northern portion of Dumoh district, for which no maps were available in former years.

Mr. Fred. Mallet had been deputed towards the close of last year, when returning from Europe, to visit and examine the vicinity of Aden, with especial reference to the possibility of obtaining a good supply of pure water for the inhabitants of that important station. The results of this examination were published immediately on his return. He showed that there was an abundance of water nearer to the foot of the hills a short distance from Aden, but that this became absorbed in the sands that intervened between these streams and the sea; in other words, that there was an abundance of good water, but that artificial means of conducting it into Aden would be requisite. There seemed nowhere such a structure as would justify the expectation of procuring water by wells sunk on the artesian principle.

Immediately on his return to India from this duty, Mr. Mallet was despatched to complete the geological examination of the southern part of the Mirzapúr district which had been left unfinished. This would carry our knowledge of the geological structure of that country southwards to the long known coal-pits of Kota, which were to be examined in greater detail so soon as the maps of the adjoining country were available. This duty Mr. Mallet effectively performed. During the recess he has been engaged in working up his maps, &c., and in a careful examination of some interesting minerals he met with in that district in connection with extensive masses of Corundum, and of which a brief account is given in the present number of the "Records of the Survey."

To Mr. Mallet I also entrusted the entire remodelling of our collection of minerals. When first the Museum was opened, the best series which our collection then afforded was brought together, and was arranged by Mr. H. F. Blanford for exhibition. This was unfortunately a very incomplete and poor series, but such as it was it proved useful. During subsequent years, this collection has been steadily kept in view, as opportunity offered of acquiring additional specimens. And as a large number of additions had been brought together by donation, by occasional purchase, and by exchange, it was determined to have the whole series remodelled. The collections had been arranged in accordance with the fourth edition of Dana's system of Mineralogy (1854), but was now brought into agreement with the last or fifth edition, 1869. Up to last year the arranged collection represented 224 species by 1,460 specimens. It now represents 358 species by 2,239 specimens. The number of specimens used to illustrate each species remains therefore about the same (6 to 7), but the actual number has been increased by 779. But as, in addition to this increase in number, many inferior specimens have been eliminated and better ones introduced in their stead, and a few which had been misnamed removed, the actual number of *new* specimens added has considerably exceeded this addition to the total number. These new specimens have been selected from the various collections stored from time to time in the Museum; from others purchased from Professors Klipstein, Krantz, &c., and from others presented by various persons or obtained in exchange, as well as from those collected in various parts of the country by the officers of the Survey.

Mr. Mallet himself had also brought back with him from Europe some very interesting and valuable additions, all of which have been embodied in the general series.

It is at all times a difficult and costly task to form a really valuable series of minerals. Many varieties can be obtained only at rare intervals and under favorable circumstances, and excepting by the purchase of some good collection, the growth of many years of constant attention, it would be impracticable now to produce any extensive and really fine collection of minerals within a limited time. The object, therefore, has been to render our series as practically useful as was possible, leaving the obtaining of handsome or showy specimens of various species to such future opportunities as may occur. The general value of the series may be gathered from a summary of the number of representatives of each group into which it is divided. We have of—

	Species.	*Specimens.*
Native Elements	14	106
Sulphides, Arsenides, &c.	48	298
Chlorides	6	16
Fluorides	6	56
Oxides	39	523
Anhydrous Silicates	75	445
Hydrous Silicates	65	315
Tantalates, Columbates	5	11
Phosphates, Arseniates, &c.	33	103
Borates	5	10
Tungstates, Molybdates, &c.	7	23
Sulphates, Chromates, &c.	22	93
Carbonates	20	198
Oxalates	2	2
Hydrocarbon Compounds	11	40
	358	2,239

The most important additions have been native Gold, native Platinum, and Platinum metals; native Sulphur from Ladak; very fine crystals of Galena; Cinnabar, Nickel and Cobalt ores; Bournonite; Tetrahedrite; soluble Chlorides from Stassfurt, Fluorides from Greenland; Cuprite from Cornwall; Hæmatite; Spinel; Magnetite; Rutile; Pyrolusite; Diaspore; Manganite; Limonite; Brucite; Psilomelane; Wad; some remarkably fine specimens of quartz and opal; Wollastonite from Auerbach; varieties of Augite and Hornblende; Tachyllite; Beryls from Donegal; Emerald from Siberia; Olivine; many very fine additions to the Mica and Felspar series; Tourmaline; Kyanite; Sphene; Dioptase; a few additions to the Zeolite series; Serpentines from the Lizard; Margarite from North America; Pyromorphite; Lazulite; Borätes, especially Boracite in beautiful crystals; Tungstates; Molybdates; some fine crystals of Crocoisite; soluble sulphates from Stassfurt; Siderite; Cerusite; Niellite and other organic compounds, in addition to many rare minerals, which were unrepresented in the collection previously.

Mr. Mallet has carried out this re-arrangement with great zeal and success. He had slight aid for a time from Mr. Alexander, but on his departure was alone in the work. And the ability with which it has been done, under excessive difficulty as to space, and other important inconveniences, and in rooms specially badly lighted, have borne ample testimony to the many advantages of study in Europe, which Mr. Mallet had been liberally allowed to reap during three months' time in addition to his furlough. The cost of this indulgence has been much more than repaid to the survey, not only by the additional knowledge so earnestly acquired by Mr. Mallet, but also by the valuable series he brought back with him.

In addition to this labour, Mr. Mallet undertook the duties of Curator, during the temporary absence of Mr. Tween, for three months' privilege leave.

Mr. Mallet has this season again taken up the examination of the Kota coal-field, extending as it does both into Rewa and Chota Nagpore.

At the commencement of the year (1871), as stated in the Report of 1870, Mr. Hughes was actively engaged in the investigation of the Wurdha river coal-fields. During the early portion of the season, his time was much occupied in meeting the district officers during their visits to the field, and in pointing out to them how much had been ascertained regarding the coal. These interruptions to his regular work móst seriously interfered with his progress, and by necessitating frequent long and forced marches to and fro, without any sufficient convenience for such rapid moving, the cost of which is such as the limited allowances of the Geological Survey do not meet, they also resulted in his being laid up by an injury to one of his feet, which for some time entirely prevented his moving about at all. He remained, however, on the ground, and continued to give advice as to the borings. As soon as able, he resumed his work, but at the close of the season he was obliged to proceed home on medical certificate.

Late in the season (May) he crossed into His Highness the Nizam's territories, and pointed out to Mr. Whyte, who had been sent by the Nizam's Government to put down trial borings in the country opposite Ballarpur, the structure of the rocks, and suitable places to work, for which aid Mr. Whyte expressed his obligation, and I am informed that the result has been the proving the existence there of more than fifty feet in thickness of coal.

During the season, the various borings carried out on both sides of the river have entirely confirmed the conclusion already arrived at with respect to this field, and have established conclusively upon what a very irregular surface the upper rocks have been deposited. The eastern boundary of these rocks was examined for a considerable distance, and they were found to be faulted against the gneiss, as far south as Sitarampett, or nearly to Moharli; here, however, the fault at the surface passes through the Kamthi rocks themselves, bringing into contact different beds of the same series. South of Moharli again the gneiss and sandstone are in contact along the boundary fault. The occurrence also of a small inlier of the Talchír rocks between Walwut and Sinála adds a convincing fact to the other evidence as to the irregular thickness of the upper (Kamthi) series, and shows the necessity for actual trials before attempting to assert definitely the depth at which, or the points where, coal may be found. The general structure of the whole field, namely, a wide anticlinal, largely denuded at the top of the curve as pointed out (by Mr. W. Blanford,) on the first examination of the area, coupled with the many instances in which the Vindhyan rocks below the coal occur in isolated and detached patches either at the surface, or at small depths below it, places it beyond a question, that this central portion of the field is one in which the flooring of the older rocks comes very near to the surface, and so irregularly that the coal, where found, will only be in small and discontinuous basins. For any large and continuous areas, we must go beyond this portion. To the west, the existence of the coal has been fully proved over a long line of country in East Berar. To the east there is no reason to assume its absence, but its occurrence has not been proved as yet.

Wurrora, where a coal-pit has been commenced, is unfortunately not, as stated, on the east scarp of the anticlinal, but a considerable distance from it, although the coal extends over a sufficient area to yield a good supply for some time.

From a knowledge of these facts, and a general consideration of the lie of the ground, I was compelled during the year, on the question being referred to me, as to 'what action should be taken in the matter' regarding the proposed line of railway to connect these coal-fields with the Bombay and Nagpore railway, to point out the facts, and to urge strongly, that if the object in view were to obtain the coal cheaply, there could be little question, that a line direct to the Woon district of East Berar would be both shorter and cheaper, and would at the same time be more effective in tapping the largest and best cotton-growing districts of the country. This line would have to cross only one large stream, the Wurdah, while the other line, as proposed to Wurrora, would have to cross four or five, of which even one, taken alone, would be heavier than the Wurdah, as shown by the estimates. I have been informed, though not officially, that after a consultation between the Chief Commissioner of the Central Provinces and the Commissioner of East Berar, this alteration in the line proposed has been recommended. If carried out, it will undoubtedly give an easy access to a very large supply of coal of such quality as occurs in this field. All that has been found is of poor quality, breaks down very rapidly on exposure and drying, and is therefore wasteful; nor will it bear very heavy draft in the fires, but with properly adjusted fire-bars and frequent care it can be used with success. The coal from near Sastu, in the Nizam's dominions, is the most durable yet raised in these fields.

In connection with this field, it is much to be regretted that some trial borings were not during the season devoted to proving the eastern slope of the anticlinal referred to above. A few well selected borings would have settled the point as to the existence of coal. As I have already said there is no reason to assume its absence, but it has not as yet been proved to be present anywhere along this line. A trial boring was put down to the east of the town of Chanda at an early date, but this having reached a depth at which the progress weekly with hand-boring was only a few inches, was stopped on the arrival of a steam-boring machine. This was at once put to work a little further to the dip, but the ground proved so soft that tubing was required, which was not available at the moment. The steam-borer was then moved to Wurrora, and has been kept there since. And no further attempt has been made to prove the coal. There is most probably a large area over which it will be found, and possibly at very workable depths. Any part of this eastern scarp of the anticlinal will, however, be much more distant from the existing lines of railway than other sources of coal, and will, therefore, be more looked to in the future than at present. There is also a very large area of His Highness the Nizam's dominions, under which workable coal will be found, and which will at some future time prove very valuable. The occurrence of nearly 50 feet of coal, as proved at Sastu by Mr. Whyte working on behalf of the Nizam's Government, is only an instance. When examining the neighbourhood of Ballarpur, in the commencement of 1870, on the opposite bank, it was stated that the larger part of the coal would be found in the right bank of the Wurdah in the Nizam's dominions. And these sinkings have quite confirmed the statement.

Mr. Hughes is still absent on leave.

Mr. Fedden was engaged in continuing his examination of the trappean rocks overlying the coal-bearing series to the west, and in clearing up one or two doubtful points as to their boundary, &c. In the jungly country of Edulabad and to the east of that town between it and the Wurdah, he suffered from repeated attacks of fever, which at last drove him from the place; and under medical advice, he proceeded somewhat earlier than customary to the hills. He has resumed his work in better strength this season, and as from the small amount of rainfall in these districts the state of the country is more favourable for work than usual, it is hoped he will be able to effect good progress.

Mr. Hacket during this season completed the district of Jubbulpur, of which he had in the previous year commenced the examination. The southern, south-eastern and south-western portions having been completed last season, the remainder has come under observation now. It was hoped also that the small district of Bijooragooghur, now attached to and forming a portion of Jubbulpur, would have been completed also, but Mr. Hacket was laid up towards the close of the season by several slight attacks of fever and its consequences, which prevented this.

The (Bijawur) series extends in a north-east and south-west direction across the central portion of the district. At the north-eastern end, on the water shed between the Nerbudda and the Mahanuddy rivers, they occupy nearly the entire surface, which intervenes between the Jubbulpur beds and the trap area to the south, and the Vindhyan rocks to the north. Here they form a considerable range of hills, the Bhitree hills, but towards the south-west in the Nerbudda valley, the section is less perfectly seen, and the rocks of the series are only seen in a few large hills isolated by the alluvium. West of Jubbulpur, with the exception of a fringe of rocks cropping out from under the trap on the south side of the valley, and of a few small hills on the northern side, the series is covered by the Nerbudda alluvium. The Bijawur series includes a great variety of rocks, of which the principal are slate, micaceous quartzites, limestone, ribboned jasper rocks, highly ferruginous and banded silicious rocks, micaceous schists, and igneous trappean rocks, both contemporaneous and intrusive. Cleavage abounds especially in the lower rocks, and often obliterates the dip; the cleavage heading east 15° to 20° north and underlying to the south at 60°. The whole series, notwithstanding very numerous local contortions, may be described as forming a shallow synclinal, the lowest group cropping out on the northern and southern sides and the higher group being best seen in the centre of the area. Four groups may be defined, though they pass gradually into each other. These in descending order are (1) the Chunderdeep group, called after the station of that name, and consisting of mica schists and limestones; (2) the Lora group, called after the Lora hills near Sehora, consisting of ribboned schists, in places highly ferruginous; (3) the Bhitree group, called after the Bhitree hills at the east end of the district, consists in places of ribboned jasper, in places of quartzites with but little of this structure, and sometimes of schists, somewhat conglomeratic; and (4) the Mujhowlee group, well seen near the town of that name, consisting of slates, quartzites, and limestone. Although these are the lowest rocks seen, they do not constitute the base of the series.

It would be of little use to enter into detailed description of these rocks without a geological map, and we shall therefore confine our observation to a very few points only. There are not many trap dykes seen, although it is possible that many exist which are concealed. Where the rocks are clearly exposed, as at the Marble rocks, several occur, offering peculiar varieties. Of the economic products of the district the iron ores are the most valuable. They occur entirely in the Lora group (with the exception of a very small quantity obtained from the laterite of Bijooragooghur). The most important mines are at Joulee; others are at Gogra, &c.: from Joulee alone fifty loaded buffaloes, each carrying about 3 maunds of the ore, are said to be despatched daily. The ore is a rich micaceous iron with hæmatite. It yielded, on assay, 68·5 per cent. of iron. Mr. Olpherts, the resident engineer at Kutnee on the Jubbulpur line of railway, has leased these Joulee mines from Government, and has succeeded in bringing the hæmatite which occurs there into use as a paint-stuff. For this, on outdoor work and especially on iron, it is admirably adapted. He has erected on the Kutnee river, near Moorwara, three or four little native constructed water-wheels, which turn grindstones about three feet in diameter, made of the Réwah sandstone. These grind the ore to an impalpable powder, after which it is dried and packed in cases. It sells retail for about £13 per ton. The excavations at Pullee are nearly 100 yards long by about 30 yards wide and 50 feet deep. There are also some old workings some quarter of a mile distant, where large excavations have formerly been made. The mines at Mungela, and at Agorea in the Mujgoan hills, and also in the hills west of the Marble rocks, are all situated on the same geological horizon, and the deposit of iron ore would appear to be very constant, and to offer a practically unlimited supply of the very best quality of ore. Small traces of copper and lead have also been found, but nowhere in quantity which appeared to offer any prospect of working them to profit.

Mr. Ball, who, as stated in last year's report, had proceeded to the south of Chota Nagpore and Sirgujah, completed last season a most admirable and largely extended reconnoissance of a very extensive area. As stated then, there were gaps, for which no maps or surveys existed, so that detailed work was impracticable. But Mr. Ball has in a very satisfactory way obtained an approximate knowledge of the limitation of the various series of rocks, which will prove of the greatest service, when detailed examination can be taken up. And all this in a country where scarcely a road exists, and where it was essential to travel with the least possible amount of comfort. I am happy to be able to report that Mr. Ball has not suffered in health from his sojourn in these jungles, generally reputed very unhealthy. This season, Mr. Ball (taking with him Mr. James Willson, who, having only recently joined the survey, required initiation into the peculiarities of the various groups of rocks), has taken up the more detailed examination of the north-western extremity of the Chota Nagpore country, of which the survey maps have been published. Mr. Ball was absent for three months on privilege leave during the recess, a holiday which he had well earned.

In Burmah, Mr. Theobald was more especially engaged in the examination or rather re-examination of the Arakan range of the Yoma. The peculiar relations of the altered rocks seen towards the centre of that range with the unaltered nummulitic rocks which occur in the flanks, to which Mr. Theobald has directed attention in papers published in the Records of the Survey, were still on many points open to doubt and question, and to determine these questions, Mr. Theobald crossed the range in several places right from the low ground of the Irrawadi to the sea coast. By these traverses he has satisfied himself that, notwithstanding the remarkable alterations to which the rocks occurring along the axis of the range have been subjected, they belong to one and the same series as the undoubtedly nummulitic rocks seen on their flanks. Mr. Theobald also paid special attention to the brine springs of British Burmah, of which he has submitted a list, which will soon be given in the Records of the Survey. The great deficiency in detail and accuracy of the maps of British Burmah which we have to use, and the densely jungly nature of these less frequented portions of the country, must for generations render the close geological examination of the area quite impracticable, and all that can be looked for is such a general sketch of the geological structure as will give a tolerably accurate idea of the relations of the several rocks.

Mr. Wynne, who during the preceding year had completed the examination of the eastern portion of the salt range in the Punjab, worked out the western part of the same area in considerable detail, and is now engaged in the country lying to the north of this range, and extending up to Attock, Hossein Abdal, &c. The strangely disturbed condition in which the rocks of the salt range are found, due not only to distinct faulting and disturbance on a large scale, but also to almost countless slips of enormous size along the bold scarp to the south,—resulting in a complicated arrangement of the several rocks, so intricate that it would be impracticable to make it intelligible without careful plans and sections—rendered it perfectly essential that the greatest care should be devoted to the proper investigation of the contained organic remains on the spot by a competent Palæontologist, and I have, therefore, taken advantage of Dr. W. Waagen's having joined the survey, and have entrusted to him a full examination of the relations and mode of occurrence of the fossils of this salt range, and I have no doubt that the results will prove highly valuable. Dr. Waagen, as will be seen from the coming number of the Records of the Survey, has already been able to throw much light in this way on the puzzling sections seen near Rawul Pindee.

Mr. Wynne's health was not at all as good as could be wished, but his zeal and earnest attention enabled him notwithstanding to work out the area visited with an amount of care and detail which is highly creditable.

I have also taken advantage of the well advanced state of the descriptions and plates of fossils to enable Dr. Stoliczka, the Palæontologist of the Survey, to visit and go over the curiously interesting sections of the district of Cutch. He proceeded thither in November, and is much indebted to His Highness the Rao and all the local officers for the most friendly aid which will enable him to see more in the short time he can devote to the work than he otherwise would have done. Valuable results have been already attained, but these will be better discussed after the examination has been completed. The entire series of fossils will prove most interesting and valuable; and Dr. Stoliczka's untiring zeal and energy will enable him to unravel, by actual examination on the spot, some of the doubtful questions as to the distribution of these fossils in the several beds and other points of high geological interest.

Mr. M. Fryar has been, during the whole year, detached on work not connected with the Geological Survey.

PUBLICATIONS.—The punctual issue of the RECORDS OF THE GEOLOGICAL SURVEY has been steadily maintained during the year. And I believe I am justified in stating that this series giving early knowledge of important facts is steadily becoming more appreciated. The numbers for the past year contain the Annual Report of the Geological Survey and Museum, and the usual quarterly lists of the additions to the Library. In addition to these, are details of the explorations for coal in the Godávarí valley, and descriptions of the accompanying rocks by Mr. W. T. Blanford: a general sketch of the geology of the Central Provinces; on the structure of the Konkan: Geology of Burmah; the Raigurh and Hengir coal-field; reported discoveries of coal in the Madras Presidency, and other papers, all largely increasing the knowledge of the Geology of India, and thus gradually building up the materials which will shortly enable a general geological map of the country to be prepared.

Of the PALÆONTOLOGIA INDICA, we have issued not only the four fasciculi due for the twelve months past, up to October 1871, but have also issued in anticipation the entire volume due for this year 1872, up to October. The great risks and uncertainties attending the execution of careful chalk drawings on stone in this climate have compelled me to anticipate our work in this respect as much as possible. From several years of trial, I found that it was only possible to be *certain* of our publication of these fossil plates being punctually maintained with our very limited staff, when we were able to keep in advance of the issue by nearly twelve months' work. We have therefore been gradually and by great exertions gaining on the issue or publication, until this year I was enabled to publish five fasciculi in one part of the description of the cretaceous bivalve fossils of Southern India. This completes the monograph of this class, and forms the third large volume of plates and descriptions of that splendid series of fossils, the finest probably ever obtained from one limited district. The Pelecypoda have been treated with the same fulness of detail as the other groups, and the volume will be found to constitute a general treatise on the classification and relations of the fossil and recent bivalves generally, as well as a detailed description of the specific forms noticed in Southern India. This volume bears stronger testimony than any words of mine could to the ability and unceasing zeal of our Palæontologist, Dr. F. Stoliczka.

The next group to be taken up, the Brachiopoda, are all arranged for the drawings and plates, and the MSS. descriptions have been completed.

In addition to the completion of this volume of the cretaceous fossils, a fasciculus has been published descriptive of some peculiar crabs found fossil in the tertiary rocks of Sind and Cutch, also prepared by Dr. F. Stoliczka.

Almost immediately on Dr. W. Waagen's joining the Survey last year, the entire series of the Cephalopod fossils, collected in Kutch, was placed in his hands for careful examination and description. For this Dr. Waagen was singularly well qualified by his intimate and accurate knowledge of the jurassic rocks of Europe, and by his previous studies in this special family of organic remains. The result has fully justified our well grounded expectations. The last number of the Records of the Survey contained a brief abstract of his researches. These are such as cannot fail to prove of the highest importance in their bearing on Indian Geology, and brief as this mere abstract is, it is certainly one of the most valuable contributions yet made to Indian Palæontology. Not less than about 80 species of Ammonites alone have been recognized, of which 73 have been procured in sufficient preservation to be specifically described. Of these 73, 37 are old and well known species, and 36 are now for the first time described. Of all these, Dr. Waagen completed the detailed descriptions and careful drawings before going to the field. These drawings are now being lithographed.

The rich collections of fossils from Indian rocks (although as a whole the greater part of the country is singularly barren of any organic remains) which have been so rapidly accumulated are now being so expeditiously and systematically examined that the publication of them is limited only by the very small sum at our disposal for such purposes. The present rate of issue of the Palæontologia Indica could be with ease doubled if funds were available.

Of the MEMOIRS of the Geological Survey two volumes are nearly ready, but have been unavoidably delayed by accidental injuries to lithographs, so that they could not be published before the close of the year.

MAPS.—Sanction having been given to the publication of the larger scale maps which, whenever available, are always used in our field examination, arrangements have been in progress for carrying out this system. It has been necessary to make several trials before finally adopting any one plan, inasmuch as it is essential that all should be published on an uniform system, of colouring, of arrangement of maps, &c., &c. Draughtsmen had also to be trained to the work, differing essentially as it does from ordinary mapping work. These preliminary and tentative proceedings will now soon be brought to a close, and I expect that a short time will see the whole in good working order. A similar series of preliminary trials has been found essential in the lithographing of the maps for final colouring. In these, we are greatly indebted to the friendly interest which Captain Murray, of the Surveyor

General's Department, has evinced in the matter. And I doubt not that a short time will now suffice to bring the system into operation, after full prevision, so as to prevent their being any interruption afterwards.

Geological sketches of several districts have been furnished to local officers for use in gazetteers. Accounts of Bombay generally, of the North-Western Provinces, of Kerowli, have thus been supplied.

LIBRARY.—During the twelve-months one thousand and sixty-eight volumes or part of volumes have been added to the Library of the Geological Survey. Of this number about one-half, namely, 529, have been presented, and 539 have been purchased. A complete list of these accessions has been given in the successive numbers of the RECORDS. I append here a summary list of those Societies, Institutions, &c., from which presentations have been received during the last year. Recently established rules for the purchase of books, by which the purchase of any book in this country, however urgently required, has been strictly forbidden, and the establishment of an agency in London, which, however good for the provision of ordinary English books, never has had such connection with the foreign scientific societies, and such knowledge of the publication of scientific works, as would enable it satisfactorily to fulfil the duties of an agent for a purely scientific establishment such as the Geological Survey Library, will most seriously delay, obstruct, and impede the successful formation of what has ever been our great want here—a good Geological Library. The delays alone will necessarily throw back our information more than half a year. Books delivered for transmission to our library in May last arrived in middle of November, those sent to India Office in July were delivered in Calcutta in middle of December. In this case the cost of transmission direct by post would have been less than the cost of the cumbrous and needless packing in boxes of wood and tin. In scientific enquiries and researches it is essential that we should have rapid and ready access to the latest publications, and delays of this kind, therefore, most seriously diminish the utility and interest of our labours.

MUSEUM.—As frequently stated, we can only maintain our collections in order by removing one series so as to make room for the examination of another, and so gradually, but with great inconvenience, bring them all into arrangement. I have already stated that during the year our mineral collection has been overhauled and entirely remodelled. This could only be done by removing from the cases a collection of rocks. This difficulty will, I fear, continue in full force until the collections have been placed in the new building intended for their reception, when space sufficient for their exhibition and careful comparison will be available. Steady progress is, however, being made in the arrangement of the large collections, and in the sorting them, so as to form, when space is procurable, duplicate series for exchange or presentation.

An index map is appended showing approximately the present state of progress of the field work of the Survey.

The various collections are in as good order and safe keeping as the limited accommodation at our command will permit.

T. OLDHAM,

Superintendent of Geol. Survey of India,
and Director of Geol. Museum, Calcutta.

CAMP, GODAVERY RIVER,
17th January 1872.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1871.

BATAVIA.—Royal Society of Batavia.
BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Royal Academy of Science.
" Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
CALCUTTA.—Asiatic Society of Bengal.
" Agri-Horticultural Society.
COPENHAGEN.—Danish Academy.
DEHRA DOON.—Trigonometrical Survey of India.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
EDINBURGH.—Royal Society.
" Royal Scottish Society of Arts.
FLORENCE.—Geological Society of Italy.
GLASGOW.—Philosophical Society.
LONDON.—Royal Geographical Society.
" Royal Society.
" Royal Asiatic Society of Great Britain and Ireland.
" Geological Society.
" Society of Arts.
" British Museum.
MONTREAL.—Geological Survey of Canada.
MOSCOU.—Société Impériale des Naturalistes.
MÜNICH.—The Bavarian Academy.
NEUCHATEL.—Society of Natural Science.
PARIS.—Comm. des Annales des Mines.
PENZANCE.—Royal Geological Society of Cornwall.
PHILADELPHIA.—American Philosophical Society.
" Franklin Institute.
" Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
SALEM.—Essex Institute.
TORONTO.—Canadian Institute.
TURIN.—Academy of Turin.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—Kais. Akad. der Wissenschaften.
" K. K. Geologische Reichsanstalt.
" Zool. Bot. Society of Vienna.
WASHINGTON.—Smithsonian Institute.
" Department of Agriculture of the U. S. of America.
ZÜRICH.—The Natural History Society.
Governments of India, Bombay, Bengal, N. W. Provinces; Chief Commissioners of Oude, British Burma, and Mysore.

ROUGH SECTION SHOWING THE RELATIONS OF THE ROCKS NEAR MURREE (MARí), PUNJAB, by WILLIAM WAAGEN, PH. D., *Geological Survey of India.*

(NOTE.—For the information of many who frequent the Sanatorium of Murree, and who may be interested in the geological structure of the hills in that neighbourhood, we give the following description of one easily accessible section close to that hill-station, the true relations of which have hitherto puzzled many observers, owing to the numerous contortions and fractures to which the rocks have been subjected. This one section will, it is hoped, serve as a key to others, and the vast importance of fossil remains as indicating the true position of the beds in which they occur, once recognized, it may fairly be hoped that greater care will in future be taken, not only in searching for these, but still more in accurately establishing the beds from which they have been taken,—a point hitherto sadly neglected).

The deposits on which Murree is built consist of red, clayey slate, with thick sandstone layers in it. These deposits are certainly younger than the Nummulitic beds, which decidedly dip under the former. It is difficult to say anything more definite as to their age, every trace of fossil (except a few bones formerly found, as I am informed) being wanting. (They are probably the representative of the true Siwaliks, further to the east). The thickness of this formation is great, but there are so many faults and contortions cutting through it that we cannot say how many times the same series is repeated, and cannot, therefore, determine its thickness with any exactness.

The true Nummulitic limestones are cut off from this formation mostly by enormous faults, so that it often seems as if the red layers were dipping under them, but in other places the superposition over the Nummulitics is very clear.

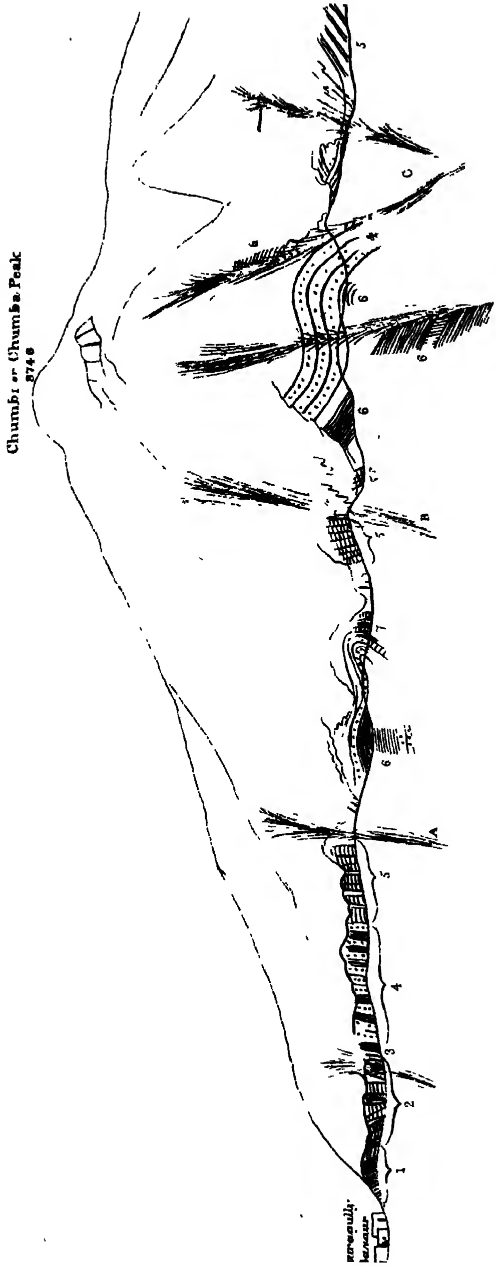
The ridge of mountains upon which Murree is built is entirely composed of these red sandstones and shales. The next ridge to the north-west, however, is, for the greater part, formed of Nummulitic limestone, which, at short intervals, is interrupted by thick beds of grey or greenish shales, in some places crowded with *Nummulites*. Even at the lowest portions of the red shales, there are some calcareous bands, which contain, but rarely, *Nummulites* and some badly preserved Pelecypods, (mostly *Lucina*), and Gastropods, (*Pleurotoma* or *Fusus*), and some fragments of Crustacea. The richest bed of the *Nummulites*, which is a greenish-grey clayey shale, appears to be rather in the upper part of the whole formation, while the lower part is composed of more compact, grey limestones, which look exactly like Triassic limestone, but which are, for the most part, crowded with organic remains, chiefly of undeterminable species, among which a very small *Nummulite* is prevalent.

In most cases there is at the base of the Nummulitics a band of black, coaly shale, of not more than from three to five feet in thickness.

Below this is a very considerable mass of sandstone in thick beds, outside yellowish-brown and of rusty aspect, but blue in color on the fresh fracture. This sandstone is, in some places, at least 100 feet in thickness. There are no palæontological indications of the age of this sandstone, but it always occurs in such close relation to the 'Spiti shales' that I am inclined to consider it of jurassic age: more especially as Dr. Stoliczka has found, in Spiti, similar sandstones, which he calls 'Upper Jurassic.'

This sandstone, if jurassic, is often the only representative of this formation, the Spiti shales, at its base, being so much crushed, that they almost entirely disappear, or they assume an aspect quite different from that which they commonly present.

The 'Spiti shales', which follow immediately below the sandstones, are of very typical aspect; black shales, with clayey concretions, impregnated with iron. The concretions which are not very distinct from the surrounding shale are not very hard, and do not, as is the case in Spiti, contain the fossils. On the contrary, the fossils here are all compressed between the single layers of the shales. At their base these 'Spiti shales' show a certain amount of transition to the next lower formation, by some beds of a calcareous sandstone and limestone intermixed with yellowish-grey shales. The limestones then



become predominant, and show, about 100 feet below the shales, some very fossiliferous bands. It is, however, impossible to obtain anything determinable out of the rock, but on the weather-worn surfaces, I observed numerous specimens of an Oyster, which I consider to be *Ostrea Haidingeri*, as well as several other things as yet undeterminable. I have little doubt that these limestones are Triassic, although the palæontological evidence is still very small. But the general aspect of the whole group is so entirely like some portions of the Upper Trias in the Alps, and further, as there are Triassic beds of the Alpine type, well known in the Spiti districts of the Himalaya, I do not hesitate to place these limestones in the Triassic formation. I have seen no sections in this neighbourhood which go deeper than the Trias.

To give a single and easily accessible section bearing out the statements just made, I will describe a line, of which a very rough sketch is given in the accompanying figure. The first glance will show what enormous contortions and faultings the rocks in this district of the Himalaya have undergone, and how difficult it must be to trace the succession of the layers, when they are cut through by faults at nearly every 100 paces, and when these faults are not visible at the surface. The scale to which the section is drawn does not allow of all the contortions which exist in reality being shown. I was compelled to limit myself to the principal ones, which determine the succession of the layers.

Starting from the Bazaar of Kaira-gully, by the backroad which leads round the Chumba Peak to Chungly-gully, one is able to observe in the first two miles of the road the following section:—

(1, 2.) At the corner, where the road branches off from the village and descends on the slope of the mountain, are some Nummulitic shales and limestones, of grey and greenish color, dipping to the north, and here and there with layers full of a small species of *Nummulite*. The Nummulitic rocks continue for some hundred paces, frightfully contorted and dipping in several directions. At last

(3.) A thin band of an entirely black, coaly clay-shale, about two feet in thickness, appears, indicating the base of the Nummulitics.

(4.) Below this a series of hard sandstones, brown on the surface, and bluish-grey inside, are observable along the roadside, intermixed with greyish shales, and here and there with a more calcareous band. The dip is uncertain and varied; often they are vertical.

(5.) After these one meets grey limestones with intercalated grey slate layers, and bands full of fossils, among them *Ostrea Haidingeri*, another Oyster, and several other Pelecypods and Gastropods, in a very bad state of preservation.

Going further along the path, the series is broken off, and, near the point A, a large fault must cut through the rocks, although this is not visible on the surface, everything being covered by débris.

Beyond the point a new series begins. The first thing which appears are a few broken-down bands of sandstone. Then follow, nearly horizontally,

(6). Spiti shales, between sandstones of nearly the same description as No. 4, both on the top and at the base, the band at top being, however, very thin. The shales contain fossils, but they are very rare. Dr. Beveridge, R. A., also tells me that he found at this spot, some time ago, a few *Ammonites*.

Above the upper sandstone follows

(7). A series of grey shales and nodular limestones, with many, but very badly-preserved, fossils. I collected here a little *Avicula* and some *Oysters*. Further on, from the road one can see very clearly that the whole of the Spiti shales and the other rocks have been overthrown, and that the lowest part of these shales, and the transition from them into the Trias, is here exposed. A little space is then covered with débris, and then typical Triassic rocks (= No. 5) are visible, thrown into a vertical position. With this the second series finishes, and the whole is again cut off by a large fault at the point marked B.

The third group begins again with Spiti shales (below them occur Triassic rocks indistinct), which are here highly fossiliferous, and dip at a high angle to the north. Here I collected *Oppelia acucincta*, Strachey, *Perisphinctes frequens*, Opp. conf., *simplex*, Sow., *Belemnites Gerardi*, Opp., *Inoceramus*, *Cucullæa*, *Pecten;* all common species of the 'Spiti shales.'

Above the shales are the sandstones, described at No. 4, well exposed and more than 100 feet in thickness. They make a slight curve, showing a little bit of 'Spiti shales' below, and then dip down at a high angle. Below on the slope of the mountain the shales are again visible, divided into two stages by a thick calcareous band; the thickness of the shales is here very considerable.

This part of the section is obviously not overthrown. And, therefore, it is clear that the portion of the shales which has furnished the fossils is the uppermost or highest.

Higher up in the next 'khud,' some more black shales are visible, but it remains doubtful whether they are not cut off by faults.

At the point marked C a great fault again cuts off the whole section, and further on, Triassic limestones appear dipping to the south-west.

The mountain-top appears to be formed of the Nummulitic limestone.

This single section will sufficiently show the difficulties which attend the study of the geological structure of these regions. It is so far a satisfactory result that we are able to show that the Nummulitics lie above the Jurassics, and the latter above the Triassic. It is as yet utterly impossible to go further than this and attempt to distinguish certain stages within the Mesozoic formations of this area.

MURREE,
November 1871.

MINERALOGICAL NOTES ON THE GNEISS OF SOUTH MIRZAPÚR AND ADJOINING COUNTRY, *by* FRED. R. MALLET, *Geological Survey of India.*

In comparison with the gneiss of many other portions of the country, which presents a singular dearth in mineralogical variety, that of the Rehr valley offers to the mineralogist a tolerably rich field. The number of species known to exist in the area now surveyed is pretty large, and further exploration will probably increase it. The following is a complete list of those found up to the present time, showing their association and mode of occurrence, but I will confine my subsequent remarks to those to which some special interest attaches:—

I.—Occurring as constituents of the gneiss.

Quartz—Orthoclase—Oligoclase—Muscovite—Biotite—Hornblende—Epidote?.

II.—Occurring in beds in the gneiss.

Limestone—Corundum—Magnetite—Quartz as quartzite and quartz schist—Hornblende as hornblende rock, tremolite rock and jade—Mica as mica schist—Epidote.

III.—Occurring in veins in the gneiss.

A.—In quartz veins and reefs—Quartz.

B.—In pegmatite veins (as constituents)—Orthoclase—Oligoclase—Quartz—Mica.

C.—In epidotic veins—Epidote—Quartz.

IV.—Accidental minerals in the gneiss.

Magnetite—Ilmenite—Schorl—Garnet—Stilbite?.

V.—Minerals occurring in the subordinate beds (II) of the gneiss.

α.—In the limestone—Magnetite—Pyrites—Hæmatite—Serpentine—Chrysotile—Phlogopite?

β.—In corundum bed—Schorl—Euphyllite—Diaspore.

γ.—In jade bed associated with Corundum—Corundum—Rutile?—Schorl—Euphyllite.

VI.—Occurring in the veins, &c., in the gneiss.

α.—In quartz veins—Micaceous iron—Tremolite—Augite—Epidote—Schorl—Muscovite.

β.—In quartz reef—Galena—Cerusite.

γ.—In pegmatite veins (as accidental minerals) Schorl—Garnet.

Felspars.

Two felspars are often coexistent in the gneiss and in the coarse pegmatite veins by which it is traversed. One, orthoclase, generally forms the greater proportion of the rock, and is seldom or never absent. The usual color is some shades of pink or red, but it passes not unfrequently into pure white. The other, oligoclase, is not a constant ingredient of the rock, and where it does occur, it is present in much smaller proportion; it is always white in color, weathering with a dull opaque surface from superficial alteration into Kaolin, and on such altered face, it is markedly distinguished from the orthoclase which weathers far less readily. On a fresh fracture the two minerals are less easily distinguished, particularly when the orthoclase also is white. The striæ characteristic of triclinic felspars are often prominently marked on the oligoclase. The following is an analysis by Mr. Tween from a specimen out of one of the pegmatite veins:—

Silica	66·24	
Alumina	20·72	
Lime	3·56	= Soda 14·65.
Potash	2·26	
Soda	9·22	
	102·00	

Mr. Tween's determination of the alkalis in similar felspar from Bundlekund gave—

Soda	13·33	= Soda 15·14.
Potash	2·76	

Micas.

The mica is usually biotite, and black or dark-brown in color. It generally occurs in small laminæ, but occasionally crystalline layers or single crystals occur with cleavage faces one-half of an inch or one inch across. Muscovite sometimes takes the place of the above, but it is less common.

The mica is sometimes associated with hornblende, and thence by gradations the rock passes into hornblendic gneiss. In the gneiss which is associated with the limestone of the Bichee Nuddee, large crystals of hornblende two or three inches across occur.

Epidote.

A very handsome epidotic rock occurs in a few places, which may perhaps be granite, but I never obtained a clear section showing what its true relations are. It is found in low hillocks to the south-west of Pokhra, being there composed of pink felspar and epidote with a little quartz. Traces of foliation (or which seem to be such) can be seen, but they are faint. Thin veins of epidote with quartz sometimes intersect the gneiss both obliquely and parallel to the bedding. Sometimes the sides of the vein are of epidote, while the centre is of crystalline quartz, the summits of the crystals pointing towards each other with a hollow in the centre as if the vein had been produced by infiltration.

Epidote as a rock in itself has been obtained in only one instance, where it occurs as a bed in the gneiss of a few feet thick.

Limestone included minerals.

Of the bands of limestone hitherto met with in the gneiss, the most remarkable is that near the mouth of the Bichee Nuddee, a stream which falls into the Rehr near Singrowlí. The rock, which is a white marble, afforded on analysis the following composition:—

Carbonate of lime	53·85
" magnesia	45·78
" iron	·34
Insoluble (chiefly minute scales of mica)	1·00
Total	100·97

being, therefore, a typical dolomite.

It is interbanded with serpentine of a rich green, and occasionally, but rarely, of a resin-brown tint, constituting a fine verde-antique marble. The purely calcareous and the serpentinous layers, say from about an inch to a foot in thickness, or in places the serpentine, occurs disseminated in spots through the limestone. Associated with the latter are layers of tremolitic hornblende passing in places almost into diallage; these hornblendic bands being traversed by irregular veins composed of quartz and largely crystallized white and flesh colored orthoclase. The limestone contains large and brilliant crystals of greyish tremolite (the tremolite in the hornblendic layers being light-green) and also large masses of a bronze colored mica, which from its occurrence in crystalline limestone, its color, and the comparatively faint degree in which it exhibits biaxial characteristics, I believe to be Phlogopite. Magnetic iron with pyrites also occurs, but sparingly. In the serpentine silky layers of light-green chrysolite of ¼ or ½ inch thick are frequently met with.

Slabs of marbles transverse to the bedding, and thus showing the alternation of limestone, and serpentine might be got to any extent of three feet across and with a little selection of five or six feet or possibly even more. The rock is quite free from silicious geodes, and would thus admit of easy sawing and grinding.

Fine grained gneiss with hornblende schist and containing crystals of hornblende two or three inches across is in contact with the limestone, the rock being so jumbled up that if the gneiss were not well foliated, one might easily fancy it to be intrusive granite.

Several other bands of limestone have been met with, of which some are serpentinous. Others again are pure white, constituting a valuable marble.* One of these latter is crossed by the road from Singrowlí to Mirzapúr a few miles from the former town.

On the right bank of the Rehr a little below Saipúr, there is a fine band, some 25 or 30 yards thick, of white crystalline marble with serpentinous layers, which may be traced for a considerable distance along the bed of the stream.

Corundum and associated minerals.

I cannot yet give a full account of the corundum bed at Pipra, as it is not included in the area geologically surveyed, and I was only able to pay a hurried visit to the place. The rock occurs in a small hill between Pipra and Kadopani (sheet 18, Rewah Survey) and about a mile east of the Rehr, the beds here having a rather irregular strike about east-west.

The section across the hill from south to north is as follows:—

a.—White quartz schist.

b.—Hornblende rock passing into jade, a few yards thick.

c.—White tremolitic quartz schist breaking with a fibrous fracture.

d.—White and green jade, including some purple corundum and containing euphyllite and schorl. The coloring matter of the jade is clearly the same as that of the mica (oxide of chromium); *c* and *d* are about equal in thickness to *b*.

e.—Bed of corundum several yards thick. It is a reddish, sometimes purple or grey, rock almost compact and crystalline in texture, and containing emerald-green euphyllite and sometimes schorl and diaspore in the seams.

f.—Porphyritic gneiss with hornblende rock. I hardly think that the corundum is in direct contact with the gneiss, but it is seen within a few feet of it, the intervening space being obscure.

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* White granular limestone also occurs in the slate veins. A very fine mass may be found at the east end of Oobra Hill, two or three miles from the Mirzapúr road.

The corundum bed is several yards thick, the surface of the hill being covered with blocks, some of which are not less than 2 or 3 tons weight, and the supply is practically inexhaustible. I was informed by a brother of the Rajah of Singrowlí, who lives at Kotah, that no corundum had been worked for five or six years, until last year, when 125 bullock loads were taken to Mirzapúr. A load is three maunds, the total, therefore, being about 13½ tons. The mahajuns pay for it at the spot 2½ rupees per 14 kucha maunds (=7 pucka maunds of 40 seers), or at the rate of 18 shillings a ton.

When two pieces of the corundum are rubbed or knocked together in the dark, a very beautiful crimson phosphorescence is emitted. When struck pretty hard yellow sparks are also thrown off, which are quite distinct from the crimson light, the latter being elicited by the slightest tap. The same effect is produced more brilliantly by striking the stone with a hammer, when the crimson light and yellow sparks flash out at every blow sufficiently hard to produce the latter. The sparks resemble those from a flint and steel, while the crimson light is true phosphorescence; this red light is so characteristic as to be of considerable use as a rough field-test for recognizing corundum. Quartz, and such other common silicious minerals as I have examined which phosphoresce at all, give a yellow or greenish-yellow light.

In 1868-69 I was informed that corundum was also obtained at Beejpúr in Mirzapúr on the right bank of the Rehr. On visiting the spot my guide took me down into one of the nullas in the alluvium and showed me several lumps lying about, but I could find none such *in the alluvium itself*, or in any bed in the gneiss of the neighbourhood from which the above lumps could have been derived. This year in conversation with a very intelligent Zemindar of Beejpúr, I mentioned the above facts, for which he furnished what seems to be a very plausible explanation—namely, that some years ago some bullock-loads of corundum from Pipra (eight or ten miles to the west) had been thrown away at Beejpúr by some brinjarries on account of more profitable employment for their bullocks or some other reason.

The emerald-green mica which occurs in seams in the joints of the corundum has been analysed by Mr. Tween, who found its composition to be as follows:—

Silica	43·53
Alumina	43·87
Oxide of chromium	·91
Lime	1·45
Potash	7·80
Water	4·60
	102·16

The high percentage of alumina and small one of silica is what might be expected in such a mineral in association with corundum, and the above composition closely coincides with that of the mineral named Euphyllite by Professor Silliman, Jr., which occurs at Unionville, in Pensylvania, in exactly the same association as our Indian one, namely, with corundum and tourmaline. The chief difference is, that the alkali in the American mineral includes both potash and soda, while in the Indian one it is wholly potash. In the mica, however, found by Dr. Smith with the emery of Asia Minor, which he originally regarded as muscovite, but on further investigation referred to Euphyllite, the alkali is almost wholly potash; the presence of 1 per cent. of oxide of chromium to which the Indian Euphyllite owes its color, distinguishing it from that of both America and Asia Minor. The following are its chief characters:—Structure micaceous; hardness = 3·5—4·0;

lustre on cleavage surface pearly, on lateral faces vitreous; color emerald-green and sensibly monochroic. The color is the same whether the light passes perpendicularly or parallel to the cleavage faces. Transparent in plates of moderate thickness. Biaxial; yields water in a glass tube. In platinum forceps emits a starry light, loses its color, and falls on the edges.

The tourmaline associated with the above is jet black with rather brilliant lateral faces, and often has a columnar structure parallel to the direction of the seam. Diaspore has also been observed, but as yet in too small a quantity to admit of description.

Euphyllite and tourmaline occur also in the jade bed *d*, the former as a scaly aggregate and the latter in a massive form. Microscopic crystals with metallic lustre and red color are observable, which appear to be white, but they are too minute to admit of chemical examination.

If I should revisit the Sone Valley next season, I hope to be able to furnish fuller information respecting this very interesting as well as valuable bed of corundum and to trace its outcrop east and west from present workings.

Magnetite.

Just north of Korchee (close to the Pangun nuddee, to the east of Gonda Hill) there is a bed of magnetite in the gneiss with a high southerly dip. It is a banded rock composed of alternate arenaceous and ferruginous layers, the latter being granular magnetite. The layers are probably due to bedding, for in a nulla near this, the sand, which is derived from this rock, exhibits a similar alternation of silicious and magnetic sand.

The rock, which is friable, is pounded up into coarse powder and smelted near Korchee, being afterwards worked up into Kolharis, &c. As the powder consists entirely of magnetic and silicious grains, it might be very advantageously washed in the Pangun nuddee, by which process the latter could be easily and rapidly removed and the yield of iron considerably increased. As usual with the natives no flux is used, so that the elimination of the silica would be an important gain.

Hornblende rock, tremolite rock, and jade.

Hornblende rock is very abundant in some parts of the gneiss, often rising into hills on account of its great hardness. Very often, however, it does not do so, and many of the largest hills are of granitic gneiss. Sometimes (*e. g.*, west of Dúmrahur and Urjhut) instead of the usual dark-green color, the hornblende is light-grey, and *tremolite rock* becomes the most appropriate term. The latter again passes into a light-grey or greenish granular to nearly compact hornblende or jade. Such is met with in many places, more noticeably between Kotamowa and Bumnee, and the top of Kurea Ghât, where bands of a foot to a few feet in thickness are interbedded with mica schist, north-west of Kisaree, where olive-green jade occurs, and associated with the corundum of Pipra.

Accidental minerals in the gneiss.

Accidental minerals are not numerous in the gneiss itself. Small crystals of magnetic iron are rarely scattered through the mass of the rock and ilmenite sand has been observed in one or two streams. Schorl is a not unfrequent mineral, and garnet is also to be found in places. It is worth noting that as far as my observation has gone, schorl is confined to the white felspar gneiss and garnet to it and to the hornblende schists, while epidote only occurs in the red felspar gneiss. Pieces of red stilbite have been found in streams, but have never been observed *in situ*. As, however, there is no trap in the district except some doubtful dykes, it is most probable that the stilbite occurs as a secondary mineral in the gneiss itself as a lining of fissures or otherwise.

About three miles west-south-west of Churchuree and one and a half south-west of Chiraikoon in Sirgoojah, near the south-west boundary of Mirzapúr, there is an abandoned lead mine formerly worked by a Mr. Burke. The rock in which it is situated is a reef of light-grey, rather shattered horny quartzite, running west-15°-north, which cuts, parallel to the strike, through rotten-looking earthy micaceous gneiss. At the mine it is double, there being one band of quartzite perhaps 50 feet thick, separated from a smaller one by some yards of the gneiss, which latter is intersected by many shattered strings of quartz. The quartzite bands have a hade of 60° to south-15°-west, the thicker being uppermost, and from the spots which were pointed out to me as those from which the ore had been extracted, it would appear to have occurred in two pockets; one near the lower side of the upper quartzite band and the other near the upper side of the lower, in both cases near the band of gneiss which separates the two branches of the reef. I observed nothing indicating the existence of a regular lode. In some specimens of the quartzite obtained from the above-mentioned spots, the ore (galena) was very sparsely disseminated. Cerusite also occurs in small crystals, and I was informed by the Collector of Mirzapúr that he believed antimony had also been obtained here. Of the latter, however, I observed no appearance.

Lead ore.

DESCRIPTION OF THE SANDSTONES IN THE NEIGHBOURHOOD OF THE FIRST BARRIER ON THE GODÁVARÍ, AND IN THE COUNTRY BETWEEN THE GODÁVARÍ AND ELLORE, *by* WILLIAM T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey.*

[*Continued from page* 115, *Records*, 1871.]

The rocks near Raigúdem differ in no way from those further to the east, nor do they require any description. Coarse sandstones and grits with conglomerates and ferruginous bands are alone exposed. Rocks are seen, for a short distance, in the Pámálerú stream, from its confluence with the Godávarí to just above Genkátapúr, rather more than a mile in a direct line, thence none occur all the way to Págalápali. In the Rálá Vagú which comes from Gúndalpád and joins the Pámálerú near Burgáwái, much felspathic sandstone and conglomerate is exposed, of the usual character with a gentle north-west dip. In one spot nearly a mile from the junction of the two streams some pink and white argillaceous stone is seen in the Rálá. At the junction with the metamorphics to Gúndalpád no Tálchírs are found. The bottom bed of the sandstones seen in the stream is soft and felspathic, grey in colour and conglomeratic with the usual Barákar character, but in a hill immediately to the south coarse loose textured pink and white sandstones are seen which precisely resemble Kámthís.

Rocks near Raigúdem.

The valley which debouches from the mass of hills to the eastward at Gúndalpád consists of metamorphic rocks, like all the more eastern hills, including the lofty mass of Rájgota. But the hills immediately north and south of the valley consist of gritty sandstones. Their eastern boundary passes nearly under Rajgotá, and is continued in a south-south-east direction for some miles; then it turns more to the eastward. From the peak of Rájgota a fine view is obtained over the sandstone country; the jungle clad hills to the south-west are seen extending away for many miles, and the rocks of which they are composed have a low tolerably uniform dip, usually from about 2° to 5°, but occasionally rather higher, to the west and west by north. It is evident with this dip and the direction of the boundary that the beds near Ashráopetta ought to be rather lower in the series than those near Gúndalpád; the former may represent

Hills and valleys east of Gúndalpád.

some of the rocks seen near Amravâram. Their appearance, however, does not support this view, but it should be added that they are very poorly seen, and that there was but little time for their examination.

Rocks near north-east boundary, south-east of Rajgotá.

The sandstone south-east of this, along the north-east boundary of the sandstone area, presents few points of interest. As a rule, the rocks, except where they rise into hills, which is not often the case, are greatly concealed by sandy clay, forming a semi-alluvial plain. The hills, so far as they were examined, are of the usual grit and conglomerate, which form so large a proportion of the field. The boundary is but an approximation laid down by a very cursory survey, and closer examination will doubtless induce its modification. In only one place was any rock seen which had a distinctly Barákar character. This lies south of the village of Bedánol, nearly due east of Áshráopetta, in a stream, and even in this case the rock was only white felspathic grit, unaccompanied by shale or any other typical Damúda formation.

Rocks near north boundary between Raigúdem and Dantalborá.

Leaving the eastern or north-east boundary for the present and returning to Raigúdem, a few words will suffice to describe the rocks near the northern boundary of the sandstone area. The rocks to the west and south-west of Raigúdem are the usual sandstones, grits and conglomerates, more or less ferruginous and possess no distinctive character. To the south stretching away to Págalúpali and Múlkalapali is a great sandy plain of jungle in which very little rock occurs. Scarcely any rock too is seen in the Kinarswámi stream.

Tálchírs north-west of Dántalborá.

North-west of Dántalbora there is a considerable tract occupied by Tálchírs. They do not run along the boundary of the sandstones, and it is impossible to say whether they extend as far as the boundary, or whether they are separated everywhere by a belt of metamorphics, as no rocks whatever are seen near the Kenarswámi stream about Dántalborá. Metamorphic rocks are, however, well seen at Gadrágúdanpali, at Koigúdem north of Sompali, and north of Sangam, and they occur in the Kinarswámi or rather in its tributary called the Morair, south of Sangam, so that they probably surround the Tálchír area in the manner represented on the map. The Tálchír beds consist chiefly of the usual shales (mudstones), but just north of Gadrágúdanpali some very fine compact sandstone is met with, which has been quarried to some extent for the anicut at Dúmagúdem. The northern boundary of the patch of Tálchírs is obscure, the country being much covered by sandy alluvium.

Unconformity of Damúdas and Kámthis on Tálchírs.

The mode of occurrence of the Tálchírs not only in this instance, but also on the outside of the sandstones elsewhere, as on the Tál, at Dúmagúdem around Narsápúr, and again on the Ganár stream, and their want of connection in all these instances with the Damúdas, point to an unusual degree of unconformity between the two groups. In the present instance, the higher sandstone beds near Dántalborá are believed to be Kámthís, but on the Ganár stream Damúdas occur, and there is the same absence of Tálchírs at the base of the plant-bearing series, and their presence in an isolated area outside the boundary.

North boundary near Palúnchá.

The range of hills forming the boundary of the sandstones from Palúnchá to Sitarámpúr fort consists mainly of grit. On the hill fort of Sitarámpúr, forming their eastern extremity, some fine red and yellow compact shale of unmistakeably Kámthí character occurs. It is not clear whether the boundary here is a fault or not, but apparently it is natural. The beds dip south close to the boundary, but north on the hill forming the old fort.

Sandstones north-west of Palúncha.

From near Palúncha the boundary turns to the northward, and a belt of sandstones, 6 or 7 miles broad west of Palúncha, connects the tract which stretches to the southward towards Ellore and Rágámáhendrí with that which extends to the Godávarí near Managúr, and thence occupies a large area to the north-west and west. The country was merely traversed rapidly and the boundaries very roughly sketched in. All the sandstone seen as far as Alápali and Markod is similar to that near Palúnchá, and the same is found from Markod for fourteen miles in a direct line eastward to Búga. From a high hill two or three miles west of Markod, all the hills in the wild jungly country, for at least ten or twelve miles west and south-west, were seen to be evidently of sandstone; beyond that distance are ranges, the outline of which is less definite, but they are tolerably flat topped and of no great height. For several miles north and north-west of Markod similar sandstone ranges appear. (Markod is north of the Atlas Sheet 94).

Coal has been found in fragments in the Kinarswámi stream near Alápali, and comes from the hills to the north-west (see Records, 1871, p. 82).

Chipped quartzite implements near Ragúndla.

Two or three miles from Ragúndla north-west of Palúnchá, on the road to Kúnáram, chipped implements of the Abbeville type were found in such abundance that 40 were picked up in a quarter of an hour within an area 50 yards square. The spot is in jungle and cut up by small ravines. Many of the implements are of white quartz. Besides those collected, nearly as many more must have been discarded as ill made and imperfect, so that the locality was probably a place of manufacture.

Boundary near Gháríbpet.

The south boundary of the sandstone area, running west-north-west from Ghárîbpet, was only crossed in one spot near Karkonda. The hills near Ghárîbpet consist to the west of garnet and kyanite schist,* the last named mineral occurring in unusual abundance and frequently of good colour. The eastern portion of the same little group of hills is composed of sandstone and grit of the usual character.

South of this the boundary can only be traced at intervals, much of the country being covered with thick sandy soil. The metamorphic rocks, which consist largely of a compact hornblendic gneiss, approaching diorite, are more frequently exposed at the surface than the sandstones; the latter are rarely seen except in the hills, which are dotted over the country, and which consist of felspathic grit often conglomeratic. Farther east, within the sandstone area, there is the same paucity of sections; a few fragments of ferruginous grit occur here and there, or quartz pebbles scattered over the surface indicate the existence of conglomerate, but sections are exceedingly rare. In all the grits fragments of clay occasionally occur.

Hills near Unáparedipalí.

The hill east of Unáparedipalí is of the usual coarse felspathic sandstone, with bands of ferruginous grit (the Kámthí iron bands) and compact red shale: some pink and lilac shale also occurs. Here again the rocks have a strongly marked Kámthí character. The general dip of the hills around this appears to be very low, not more than 2° or 3° to the eastward. About four miles south of Pentlam, on the road to Kistnavâram, in a nulla, a great thickness of the red purple and yellow compact shale is seen, dipping east or east-north-east.

Near Krishnavâram.

At the western end of the tank at Krishnavâram is some very calcareous rock, apparently a schist strongly impregnated with carbonate of lime. This must be just outside the sandstone boundary which probably

* This rock was seen and described by Voysey.—J. A. S. B., II, p. 399.

runs through the tank. A hill east of Krishnaváram (probably Kistnáváram), and another further south, are of precisely similar grit to that of which the other hills to the northward are formed. The dip is very slight, if there be any.

From this to Vaimsúr, five miles further south, there is undulating country with a sandy soil, through which no rock appears. At Rajerlá metamorphic rocks occur in a well, and there is a hill of crystalline rock just east of Vaimsúr, but (partly from want of time for more careful examination) no boundary was traced from near Kistnáváram to Chintalpúdi. Near this town metamorphics appear rather more than a mile to the south on the road to Ellore, whilst at the town itself sandstone is seen in several wells. It is felspathic, and the colour is variegated. Thence the boundary makes a curve to the eastward (not examined), and then runs with a rather irregular outline for about ten miles to the westward south of Chatrai.

Country near Chatrai and Núzed.

Around Chatrai (Chataroye of map) the metamorphics are well seen, and to the south of this the boundaries of the sandstone are fairly exposed. There is but little jungle, and the country is mostly open. The bottom beds of the sandstone series are admirably seen in several places, for they rise into low, flat topped hills, the base of which are sometimes of metamorphic rocks, upon which the sedimentary formations are seen resting. This is the case at Rámákápetta north of Núzed (Noozudoo or Noozeíd of the map) and at Ravacharla to the south. Here the lowest beds of the sandstone consist of white, pink and brown felspathic grits, and hard dark reddish-brown ferruginous bands, more or less gritty and conglomeritic. A little further north, as on the hill near Somávaram, and throughout the rises east and south of Núzed, similar beds are associated with variegated felspathic sandstone, fine, white argillaceous sandstone, and red and yellow hard compact shale. All these beds are typically Kámthí in their character, perhaps they resemble the beds at Sironchá more than those of Chánda and Nágpúr, but they differ greatly from the Damúdas of Lingálá and Mádaváram.

Sandstones near Núzed.

The dips are generally low, often nearly or quite horizontal, as in the hills west of Sepúdi. The hills are depicted on the map of absurd height, judging from the hill shading; in reality they are low, flat topped rises, rarely exceeding 100 feet above the plain. The form as represented is also frequently inaccurate in detail.

That the beds are Kámthís, and not of higher horizon as Panchets,* is shown by the occurrence of *Glossopteris*, some leaves of which were found in sandstone dug from a well close to Somávaram.

The base of the sandstones is not seen everywhere, for instance, around the tank north of Somávaram and thence to the eastward, and there is of course a possibility of Damúdas occurring in such places. Wherever the basement beds were seen however, they were Kámthís, so far as could be inferred from their mineral character, and there was the usual want of carbonaceous shales and other indications of coal.

Metamorphics, limestone, &c.

The metamorphics were not examined. Some limestone occurs in the crystalline rocks both north and south of Chátrai, (Chataroye) but it looks impure. West and south-west of Núzed the metamorphic rocks form fine masses of hills.

Iron furnaces.

Some iron furnaces at Chítápurn near Cománaram, and others subsequently seen are cylindrical, of greater bulk than usual, being about 4 feet in diameter and the same in height surmounted by a cylindrical chimney a foot or 18 inches in height. The ore is decomposed ferruginous stone abounding in iron peroxide and probably derived indifferently from the surface of the sandstone and of the metamorphics. The blast is obtained from hand bellows of a larger size than usual, each worked by one man, two bellows to each furnace, the out-turn from each furnace appeared to be considerable, 60 or 70lbs. per diem from sunrise to sunset. It is refined by the same men, not sold in the impure state.

Old Diamond mines at Golapali.

The low rises south of Golapali are covered with the remains of old diggings, said to have been diamond mines. I could not learn how long a time has elapsed since the works had been abandoned; an old man, at least 60 years of age, told me there had been no mining within his recollection, and the pits have all fallen in, the whole country being covered over with thick bush jungle. The diggings appear not to have been in the sandstone itself, but in the very gravelly laterite which rests upon the sandstone, but the surface is so much broken and altered by the pits that it is difficult to say. The workings evidently cover a very considerable area, and are part of the old diamond mines of Golconda,* the ancient name of the hill range north of the Godávarí and the adjoining country.

Rocks north of Ellore.

Similar low flat topped hills of Kámthis extend across the country north of Ellore, becoming gradually less distinct to the eastward. The character of the rocks is precisely the same as near Núzed. South of the low rises, there is a belt, generally three or four miles broad, of undulating grounds, very sandy, and evidently derived from the waste of the sandstone, which is probably but a short distance below the surface. Without closer examination it is difficult to say whether the sandstones can be sufficiently traced in this tract to justify the drawing of the alluvial boundary to the south of it, but probably they can. Thence to the sea all is believed to be flat alluvium.

Country north-east of Ellore.

The hills scattered over the country north-east of Ellore appear to be a continuation of the same Kámthís. Hard ferruginous gritty bands are common, and fragments of them are conspicuous on the surface. In the hills near Kunlácherow, 16 miles north of Ellore, *Vertebraria* occurs in a grey compact hard stone, which appears to be calcareous.

The hill just south of Tándkalpúdí consists of fine hard variegated sandstone, with something of the peculiar vitreous character and conchoidal fracture, typical of particular bands in the Kámthí beds at Bokhárá near Nágpúr, the tank of Taláigáon, near Mángli, and on Malárgar west of Chándá. The dip is to the east and very low, not exceeding 2° or 3°.

South-east of this there is much laterite stretching away to the borders of the sandy alluvium. As a rule, however, laterite is but poorly developed in this country, and there is no well marked belt of it along the edge of the alluvium as is the case to the northward in Orissa.

On the hills east of Ragavápúram there is a very low south-east or east-south-east dip of about 1° or 2°. Twelve miles further to the east-north-east, and north of Gopálapúram, the dip is south or south-south-east. The beds seen in the latter locality are very nearly the base of the series, as metamorphics come in just north of them, and amongst the Kámthís a dark purplish sandstone of fine texture, highly ferruginous, felspathic and slightly micaceous is well developed. The same is seen to a considerable extent in the hills to the north-east near Bímúlú, also close to the boundary. On this rock there is often a coating of

* See Voysey, J. A. S. B., 1833, p. 403; Newbold, J. R. A. S., VII, p. 232.

hydrous iron peroxide, as on laterite. The sandstone hills were seen stretching away to the Godávarí, south of Palavâram, but were not further examined.*

Traps near Pangadi.

The hills west of Pangadí consist principally of trap, overlaid in part by sandstone or conglomerate; underlying sandstone only appears on their northern edge, close to Dúdúkúr. The fossiliferous limestone band is distinctly intertrappean, but at a small height above the base of the volcanic rocks. The trap is fine grained and compact, decomposing into the usual soft earthy greenish rock. All around, so far as was seen, the country is covered with black cotton soil, and agate fragments are scattered about as in the Nágpúr country.

To the eastward the hills are thickly capped with ferruginous grit and conglomerate, precisely resembling that in the Kamthis and probably derived from their waste. This rock is well seen near Daicharla and south of the bungalow at Pangadí. In the latter place it consists of coarse white speckled felspathic sandstone yellowish-brown in colour with ferruginous bands. The trap can be of but little thickness, probably not more than 200 to 250 feet. It is seen on the road from Pangadí to Rajamahendri and reappears north of the latter town, whilst the overlying sandstone appears to form the hills at Dowlaishwaram.

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* I am informed that the sandstone is also found east of the Godavárí in this direction.

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SECRETARY, MINING DEPARTMENT, VICTORIA.

January 6th, 1872.

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OF THE

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VOL. VI, Part 1.

1873.

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RECORDS

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1873. [February.

Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1872.

During the twelve months of 1872 our working staff was diminished in number by the absence, either on leave, or on special duty elsewhere, of several of the officers of the Survey.

As stated in last year's report, Mr. W. T. Blanford was deputed to accompany the Boundary Commission in Beluchistan and Persia. Two very interesting papers on parts of the Persian Gulf and of the shores of Arabia visited by Mr. Blanford, while waiting for the arrival of his fellow labourers, have been given to the public during the year. Later on, at the close of the boundary labours, he was compelled by ill health to proceed direct to Europe, where he arrived in September. It is to be hoped that he will be able to work up the extensive and valuable materials he has acquired, together with those of his colleagues in the duty. Taken as a whole, it is certain they will form one of the most valuable contributions to the Natural History of a little known portion of the earth's surface, which offers many points of high interest and importance, in so far as it forms a connecting link, as it were, between our Indian empire and the wide areas of Arabia on one side and of the Caspian and Russia on the other. Mr. Blanford also had opportunities not often offered to European naturalists, which, I doubt not, he made ample use of. On this duty he has been absent during the whole twelve months. Mr. Foote was absent for three months from August to November. But this interfered only slightly with the progress of the work. Mr. Fedden, who had been suffering from frequent attacks of fever in the unhealthy district of the Pemgunga and Wurdah valleys, left the country on sick leave in May, and has been absent since. Mr. Hughes, who had been invalided in the same districts during the working season of 1871-72, returned to duty and resumed his work in November 1872, and has since been actively engaged. Dr. Waagen was also compelled to leave for Europe on medical certificate at the close of the year. Mr. J. Willson, who had been absent on sick leave from May, resumed his duties early in December, and at once proceeded to the field. These constant changes, necessitated in a great measure by the heavy work and great exposure to which the assistants of the Geological Survey are subjected, unavoidably retard progress and delay the completion of maps.

At the commencement of the year (January 1872), Mr. Medlicott was actively engaged in the examination of the Satpura coal-fields and adjoining country. Some of the results of this examination are already published. Of these results the most important, practically, were two—the possibility of coal being found to extend under the more recent deposits of the Narbada valley proper outside the hills, and the probability of beds of workable coal being traced more to the south in the Dudhi valley. To test the former, Mr. Medlicott recommended that boring trials should be made near Gadurwarra, and this has been commenced. The actual borings have been placed under the charge of Mr. Collin, a coal engineer who had been engaged at Wurrora in the Chanda district. But badly supplied with tools, and at a distance from any place where mechanical appliances and instructed labour could be obtained, the progress hitherto has been very small and very disappointing. Mr. Medlicott is only responsible for the proper selection of the locality, the actual working being under different control. The false economy of attempting to carry out such an undertaking without proper tools and efficient supervision cannot be too strongly insisted on. Mr. Medlicott meanwhile has been endeavouring to push on the geological examination of the adjoining country, this being the necessary preliminary to any further practical search for coal, his progress in this being, however, most seriously retarded by the necessity of looking after boring operations so inefficiently conducted, without any countervailing advantage.

Mr. W. L. Willson has been steadily engaged in extending the geological lines and boundaries, from the north of Dumoh, where he had been engaged, into Bundelcund and the adjoining territory of Rewah. The district examined is as yet incomplete in itself, and any description must be deferred. Mr. Willson was, during the recess, most usefully employed in the preparation of the maps of Dumoh district on the scale of 1 inch = 1 mile for publication, some of which are now ready.

Mr. Mallet, who had, as reported at the close of last season, proceeded to the coal-fields of Kota, on the southern borders of Mirzapûr district, mapped out its limits. He notices some fourteen outcrops of coal, most of them, however, very thin and worthless; some two or three have a workable thickness of fair coal. All appear to be on about the same horizon, not more than two being seen in any cross section, the richer outcrops thus appearing to be only local. Mr. Mallet has also added many interesting mineralogical observations to those in his previous report upon the rocks occurring in the widely spread gneiss series, especially upon the valuable bed of Corundum which he had noticed in that neighbourhood. These notes having been published in the Memoirs of the Survey need not be alluded to here more particularly. During the later part of the year, Mr. Mallet has taken up the examination of the Hazaribagh district. A considerable part of this district had been gone over some years since, but the topographical maps, which were then available and which were shortly afterwards condemned, were so imperfect, and those resulting from the re-survey so entirely different, that it has not been found practicable to transfer the geological lines, &c., without absolutely going over the ground a second time. Mr. Mallet's labour will be confined chiefly to the crystalline and metamorphic rocks. In a similar way, Mr. James Willson has been, since his return from sick leave, engaged in putting in the geological boundaries and divisions of the coal-fields in the south of the same district on the new maps preparatory to publication.

In the early part of the season, Mr. Ball was engaged in the examination of the coal-bearing rocks in Sirguja. Among these areas, the small coal-field of Bisrampúr is in itself complete, and will shortly be published. Among these rocks Mr. Ball has noticed a case of unconformity between the lower group, or the Barakár rocks, and the upper sandstones, defined by faulting in the lower rocks not affecting the upper. This is a very unusual occurrence, but is of high interest if established by further research.

In the latter part of the year, Mr. Ball has been deputed to accompany Mr. H. Bauerman, who had been sent out by the Right Hon'ble the Secretary of State, in his visit to the more important iron-yielding districts, with a view to giving a definite opinion on the feasibility of establishing iron works in India, and with him has visited

Birbhúm, Raneegunj, Hazaribagh, &c. Mr. Bauerman's report will be submitted to the Secretary of State.

Mr. Hacket has carried his lines and divisions from the adjoining districts of Jabalpúr and Bijiragoogurh into Rewah. A very large part of this area is covered by the Jabalpúr formation. It is seen typically in the north-west of the area, but is extended by Mr. Hacket considerably to the south of Bandogurh. The Bandogurh sandstones are themselves 1,000 feet thick. How far this apparent extension of the formation can be proved to be the fact must be seen from the adjoining country when it comes to be examined. In the present season Mr. Hacket has been sent to work out the details of the more recent deposits of the Narbada valley in connection with the Satpura basin, which Mr. Medlicott is examining at the same time.

Previously to his departure on leave, Mr. Fedden had extended to the south his examination of the rocks of the Nizam's territories adjoining Chanda, tracing out the existence of a group of rocks under the great Deccan trap to west of Sirpúr, containing remains of *Palæozamia,* thus establishing their relations with the upper jurassic rocks of Kutch and the Rajmahal beds of Bengal, and giving another clue towards unravelling the connection of the so-called Jabalpúr beds of the Narbada valley with the others. The full extent of these rocks remains to be worked out.

In the Punjab, at the opening of the year, Mr. Wynne and Dr. Waagen were engaged in the detailed examination of the Salt-range and adjoining country. This has enabled the mapping of the whole of that range to be completed, while a remarkably interesting and extensive series of fossils has been obtained, which have as yet been only partially examined, but which, when fully investigated, promise to open up some very important and intricate results. One of these discoveries I will notice again. At the close of the working season, Dr. Waagen returned to Calcutta and took up the detailed examination of the Cephalopoda from Kutch, our previous collection of which had received very extensive additions from the labours of Dr. F. Stoliczka. This group will form one of the most important contributions to the Cephalopoda fauna of the upper jurassic formations (from the Tithonien to Callovien) ever published. The extent of this group alone, without any of the other classes of Mollusca, may be estimated from the fact that their illustration will require about 60 large quarto plates. The MSS. of the descriptions have been nearly all completed, and great progress has been made in the preparation of the plates. But it was with much regret that we were obliged to suspend the work,—only temporarily, I hope,—in consequence of the serious illness of Dr. Waagen, who had commenced it, and whose wide and accurate acquaintance with the Cephalopoda rendered his descriptions highly valuable. I sincerely trust that a few months and a better climate may restore Dr. Waagen to the enjoyment of full health, and enable him to resume and complete his history of this most interesting fauna.

Towards the close of the year, Mr. Wynne had resumed his examination of the Punjab rocks, but was necessarily diverted for a time to enable him to aid in procuring and forwarding a complete collection of the salts and rocks of the Salt-range and its salt mines, to be sent to the Vienna Exhibition. Having accomplished this, he resumed the detailed examination of the country north of the Salt-range. A brief but careful description and sections of the well known hill of *Sirban,* close to Abbottabád, has been published during the year—a result of the joint labours of Dr. Waagen and Mr. Wynne. This has been given without delay, both because the hill is close to a well known station, and so accessible to those who desire to examine its structure, but also because this structure had been entirely misrepresented; while it would at the same time form a typical illustration of what might be looked for in other similar areas.

In Madras Mr. W. King had, at the commencement of the year, taken up the examination of the country adjoining the Godávárí, in continuation of the preliminary survey of the same area which had been carried out by Mr. Blanford, whose health did not admit of his returning to that district. As it was important that the more southern portion of the country should be carefully examined prior to proceeding to the less accessible area further north, Mr. King's attention has been chiefly directed to the country extending between Dumagudiem and Kummummett. Some of the principal results arrived at have been already published in the Records of the Geological Survey for 1872, so they need not be detailed here. In one place, a limited area of coal-bearing rocks was traced out, and actual beds of coal found; but the country is so covered with jungle, and so thickly coated with debrís and recent deposits, that nothing very definite can be asserted regarding the extent or value of this coal without borings. Another small area near Ashwarowpetta holds out some promise, but this also must be actually tested before any satisfactory conclusion can be arrived at. Towards the close of the year, when it was too early in the season to enter the jungly country to the north with any safety, Mr. King has made a careful examination of the country between the Godávárí, and Rajahmundry, and the sea, and has there found some fossiliferous beds, the organic remains from which will prove of high interest. He has also brought the well known fossiliferous beds of Kateru, near Rajahmundry, into stratigraphical relationship with those occurring at Pungady on the opposite bank of the Godávárí—here a stream of great width. As the jungles become drier and more accessible, Mr. King will extend his researches northwards.

Mr. Foote has been steadily carrying out the boundary lines between the great area of the Deccan trap rocks and the underlying beds; and between those intermediate beds and the gneiss rocks on which they rest. He has connected his lines with those previously mapped in by Mr. Wilkinson to the west. The entire area examined, excepting a few square miles on the top of the plateaux, is within the drainage basins of the Kistna, Gatpurba, and Malparba rivers. Mr. Foote has also been fortunate enough to add to the valuable series of fossils, bones, &c., of *Rhinoceros*, which he had obtained during the previous year, and to find others of bovine animals, together with deposits of fresh-water shells, which on examination proved to be very similar to those found with the ossiferous clays and gravels of the Narbada valley. There can be no question that these ossiferous beds will prove of the very highest interest when fully worked out, as bearing on the distribution of genera in these pleiocene deposits, which still exist in other areas, but which have entirely ceased to exist within the limits of the districts where their remains are found.

In Burmah, Mr. Theobald has been engaged in extending his examination of the country between the central range and the eastern boundary of the country on the Sittang river. The present season will see the completion of his examination of British Burmah proper; and a map and general report will then be prepared for publication.

Dr. Stoliczka, in the early part of the year, completed his detailed examination of the Province of Kutch (Kach'h), in which he has been enabled, by the application of his palæontological knowledge, to define several well marked sub-divisions or horizons in the jurassic rocks, and to establish their close relationship to the acknowledged groups in European classifications. The full details of these are being prepared for publication, while the magnificent series of fossils also obtained will be worked out as soon as possible.

PUBLICATIONS.—The RECORDS OF THE GEOLOGICAL SURVEY OF INDIA have appeared with regularity at the established three-monthly intervals. In the series for the past year, besides the Annual Report of the Survey, papers, more or less in detail, have been given, treating of very varied subjects and localities. It would have been impracticable for a considerable time to come to publish a detailed account and map of the complicated structure of the hills flanking the great Himalayan range in the Punjab; and it seemed, therefore, desirable to give at once a brief outline and description showing the relations of the rocks and their general physical aspects and structure.

For this purpose, a section close to the most frequented station in those hills, Murree (Mari) was taken. Dr. W. Waagen has pointed out very clearly the distinctions of the beds, as indicated by their fossils. Such a sketch ought to suffice as an index or guide to other observers in the adjoining districts. Descriptions of the mineral contents of the gneiss in the district of South Mirzapúr are given by Mr. F. Mallet, who has pointed out the occurrence there of a very valuable deposit of Corundum, which is also of high interest from its associated minerals being identical with those occurring in America in the same association.

The sandstones of the Godávárí are described by Mr. Blanford, while Mr. King, who took up Mr. Blanford's work there, describes in more detail the southern portions of this area near Kummummett, and shows the occurrence of coal there in quantities which will repay the expense of working when the field is rendered more accessible. Mr. Blanford also contributes two valuable sketches of the geological structure of the Beluchistán shores of the Persian Gulf, as well as a notice of Maskat and Massandim on the coast of Arabia. Mr. Medlicott describes in detail a very remarkable case of what appears to be only local jointing in some sandstones at Jabalpúr, and a careful discussion of the physical relations of the 'Lameta' group. Mr. Theobald has given a notice of petroleum localities in Pegu, and further discussion of the relations of the 'axial' group in Western Prome, while, in addition to these more local and limited notices, a general sketch of the geology of Orissa, and another of the geology of the Bombay Presidency, were also published—both drawn up by Mr. Blanford. This brief enumeration of the principal contents of the numbers will show how much has been done to elucidate the geological structure of the parts of India and adjoining countries in which the officers of the Survey have been engaged.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY two volumes have appeared. It was stated in last report that these were well advanced. Both Vol. VIII and Vol. IX have been issued during the year just closed. In the first of these, Vol. VIII, in addition to brief accounts of three small, isolated, and unimportant coal-fields in Bengal, a long and detailed account is given of an immense area, nearly as large as England, to the north of Madras town, including the districts of Kurnool and Kuddapah, with maps and illustrations. Vol. IX includes a notice of the Peninsula of Kutch (Kach'h), a description of the geology of the vicinity of Nagpúr, a notice of the geology of Sirban hill near Abbottabád in Punjab, and a brief notice of the occurrence of Ammonites in beds, in the Salt-range, containing other fossils universally admitted hitherto as of carboniferous age. This last is one of the most striking discoveries which has marked the progress of Palæontology for many years. The occurrence of the Brachiopoda, *Athyris subtilita, A. Roissyi; Producta costata, P. longispina, P. Humboldtii,* in the same beds would at once be admitted as abundant evidence that those beds belonged to the true carboniferous group of Europe, but with them also occur *Strophalosia Morrisiana,* which would rather indicate a Permian age. There is, however, no question whatever that the association of fossils points conclusively to a Palæozoic epoch, whatever doubts there may be as to the exact horizon in the palæozoic series to which the beds may belong. Now, the occurrence of a true Ammonite in any of the palæozoic rocks is a fact altogether new to stratigraphical palæontology, and opens up a whole field of investigation of the highest interest. The examination in detail of the beautiful series of fossils obtained from the Salt-range has unfortunately been interrupted by the serious illness of Dr. Waagen, who has been obliged to proceed to Europe on medical certificate, but when completed, this collection will exhibit other novelties besides those already noticed.

Of the PALÆONTOLOGIA INDICA, during the year terminating on 31st December 1872, the portions descriptive of the cretaceous Brachiopoda and of the Ciliopoda have been issued. In the last reports we pointed out the rapid progress which had been made in this series, and showed that the rate of publication was limited chiefly by the amount of funds it was possible to devote to it. The question commended itself to the favorable consideration of the Government of India, and it is with pleasure I acknowledge the liberality which has doubled the sum granted for this valuable series from the commencement of the next financial year. Meanwhile efforts are being made to instruct the necessary artists, lithographers, &c., so as to be ready to take advantage of this. We had, during 1871, issued, as then stated, the portions of the work which represented the fasciculi due up to October 1872. The two parts since issued have been large ones, while the Echinodermata are printed off and only await the completion of the plates. There remain, therefore, the corals to complete the issue of all the groups of invertebrata represented in the cretaceous rocks of South India. These parts combined will form the fourth large volume of the Cretaceous fauna, and will complete the monograph of this very important group. It will form a monument of skill and labour reflecting the very highest credit on the Palæontologist of the Survey, Dr. Stoliczka, and will prove a very fitting description of one of the richest and most varied faunæ ever obtained from a limited area in a limited formation.

A fasciculus of the Cephalopoda of Kutch is ready for issue. This contains all the *Belemnites* and *Nautilidæ.* It was hoped that we should have been able to continue this series without interruption, the succeeding portion being very well advanced; but the illness of Dr. Waagen already alluded to has disappointed this expectation. The series of the Cephalopoda is very extensive, and will prove a contribution to the fossil history of the upper jurassic rocks of the very highest importance and value.

In addition to the regular issue of the *Palæontologia Indica*, some of the more remarkable forms met with in the Salt-range, as already noticed, have been figured in the Memoirs of the Survey.

MAPS.—Some of the sheets of the district of Dumoh, which had been taken up first for publication on the larger scale of our field maps, or 1 inch equal to 1 mile, are ready, and have been kept back until the whole district be completed, which will be very shortly now.

Of the 'Atlas of India' maps, which are to be used as the final record of our work, six quarter sheets were ready for issue to the public at the close of the year. Of these, the four quarter sheets of sheet 79, containing the larger portion of the Cretaceous area of Madras Presidency, were prepared some time since, but had not been issued, awaiting the completion of the adjoining parts. Two quarter sheets, north-east and south-east, of sheet 78 were printed during the year, and the parts of sheet 77 are now in the hands of the engravers. A small map is annexed showing the present state of the publication and preparation for publication of these final maps. These are now printed in colors with much success at the Surveyor General's Lithographic Office, and the general system having been established after several trials, the rate of issue can now be maintained with some regularity.

LIBRARY.—During the year, seven hundred and ninety-six volumes or parts of volumes have been added to the library of this department. Of this number 489 have been presented and 307 have been purchased. As usual, a list of Societies or Institutions from whom we have received such presentations or exchanges is annexed, while each successive number of the RECORDS has given a list of the additions received during the preceding three months. I rejoice to think that this department has been relieved from the injury resulting to its library from the restrictions imposed on the mode of procuring books, and from the delays consequent thereon. And I doubt not the coming year will again show a return to the larger number of volumes which we have been for years past in the habit of recording. Advantage has been taken of the past year to bring up the binding and securing of our valuable series so far as practicable.

MUSEUM.—The collections in the Museum have been maintained in good order, the additions properly embodied in the general series, and the specimens properly cleaned out and carefully labelled. The collection of minerals, which, as reported last year, had been entirely remodelled and added to so largely, has been in part carefully catalogued by Mr. F. R. Mallet, and it is hoped that this valuable work may be completed during the coming rainy season, when work in the field is impracticable.

The demand for the preparation of a good series illustrative of the mineral wealth of this country to be sent to the great Exhibition in Vienna has entailed on all the officers of the Survey a large amount of trouble and occupation during the last months of the year. The extremely limited and unsuitable accommodation which the present Museum house offered for such extended collections has always prevented our bringing together a collection properly representing the mineral resources of the country. In fact, we had no place to put such a collection if made. While, therefore, our series afforded good specimens in one or two directions, it was necessary to procure fresh and good sized specimens for Vienna. I would here acknowledge the great liberality and very cordial co-operation which I have experienced on the part of the numerous colliery proprietors in the country, who have supplied us with excellent specimens of the coals, ores, tools, &c., from their districts. I am also indebted to the Commissioner of Inland Customs for a very valuable series of specimens illustrative of the salt deposits of India. And in brief, from every one to whom we applied for aid, we have received most ready support. The time at our disposal was far too brief to admit of anything approaching to a complete series being obtained, but that which is to be sent will give a fair representation of the mineral wealth of the country. With the special sanction of the Government, it is proposed also to send some of our unique and valuable collections of fossils, which will excite great interest among the Geologists of Europe, and will afford a much desired opportunity for actual comparison and identification with known European forms.

An Index map is, as usual, appended showing the present state of progress of the field work of the Survey.

The various collections are in as good order and preservation as the limited accommodation at our command will permit.

T. OLDHAM,
Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
February 1873.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1872.

BATAVIA.—Royal Society of Batavia.
BERLIN.—Royal Academy of Science.
DITTO.—Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
CALCUTTA.—Asiatic Society of Bengal.
DITTO.—Agri-Horticultural Society.
CAMBRIDGE, MASS.—Museum of Comparative Zoology.
CHRISTIANIA.—Royal University of Christiania.
COLUMBUS.—Geological Survey of Onio.
COPENHAGEN.—Danish Academy.
DEHRA DOON.—Trigonometrical Survey of India.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Dublin Society.
EDINBURGH.—Curators of the Signet Library.
FLORENCE.—Geological Commission of Italy.
GLASGOW.—Philosophical Society.
GÖTTINGEN.—The Society.
LAUSANNE.—Society of Natural Science.
LONDON.—Geological Survey of Great Britain.
DITTO.—Royal Society.
DITTO.—Royal Asiatic Society of Great Britain and Ireland.
DITTO.—Geological Society.
DITTO.—British Museum.
MONTREAL.—Geological Survey of Canada.
MÜNICH.—The Academy.
NEW HAVEN.—Connecticut Academy of Arts and Sciences.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—L'Administration des Mines.
PHILADELPHIA.—American Philosophical Society.
DITTO.—Franklin Institute.
DITTO.—Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
ROORKEE.—Thomason College.
SALEM.—Essex Institute.
DITTO.—Peabody Academy of Science.
TURIN.—Academy of Turin.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—K. K. Geologische Reichsanstalt.
WASHINGTON.—Smithsonian Institute.
DITTO.—Department of Agriculture of the United States of America.
YORK.—Yorkshire Philosophical Society.

Governments of India, Bengal, North-Western Provinces, Punjab; Chief Commissioners of Mysore, Central Provinces, and British Burmah; Surveyor General, and Superintendent, Great Trigonometrical Survey of India.

SKETCH OF THE GEOLOGY OF THE NORTH-WEST PROVINCES, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The geology of the North-West Provinces is conveniently separable into three divisions, corresponding to three distinct geographical regions. Twenty-three of the thirty-five revenue-districts are entirely on the Gangetic plains. Three districts on the north—Dehra-Dún, Garhwál, and Kumáon—belong altogether to the Himalayan region. Out of nine districts on the south, seven are in very large proportion covered by the plains-deposits; three only being in whole or in great part within the rock-area of the Peninsula of Hindustan. It is at once apparent that these geographical divisions are also strictly geological; and it may be here stated that no identification has as yet been made out between the rocks within these provinces on the north and on the south of the plains. The formations of these several regions may be noticed in the following order:—

I.—*The Plains.*—Terms applicable to these deposits. Bhángar and Khádar lands. Whether the great rivers are raising or lowering their Khádars. Bhábar and Tarai land. Age of the Bhángar land. Kalar lands.

II.—*The Himalayan region.*—Physical and geological divisions. The Sub-Himalayan series: Sabáthu group; Náhan group; Siválik group. The limestone and slate series: The Krol, Infra-Krol, Blini, and Infra-Blini groups. The metamorphic series.

III.—*The Peninsular region.*—The coal-bearing series: Barakár and Talchír groups. The Vindhyan series: its characters: its distribution. The slate series. The schist and gneiss series.

I.—THE PLAINS.

Terms applicable to these deposits.—The middle region naturally claims first attention. It is often spoken of as 'the alluvial plains of the Ganges,' or by such like expressions. In a general sense these terms are admissible: there is no doubt that the materials forming the plains were contributed by the Ganges and by its tributaries. But in this range of meaning the Siválik deposits might claim to be included; for it has been shown that their materials, too, were conveyed through the existing Himalayan drainage system. On the other hand, by confining the word 'alluvium' to its strict geological meaning—to ground subject to flooding from the very channels that now exist—the alluvial ground of the North-West Provinces becomes comparatively small. It is necessary to specify still further to bring out the distinction to be made in the area under notice: the word 'alluvium' is scarcely understood unless as applied to fine deposits from tranquil inundation; and it applies to such indiscriminately; whereas from the proper geological point of view, the distinction to be indicated is what ground is undergoing increase from whatever form of deposition, and, on what ground abrasion (denudation) is in permanent action; or, in other words, where river action is formative and where it is destructive.

Bhángar and Khádar lands.—A large proportion of the plains-area in these provinces is permanently undergoing denudation. The main rivers run through it in confined and fixed valleys, the flood-level of the waters being well below the general level of the country. Several considerable streams, as the Hindan, take their rise within this area; and though subject to local overflow, with deposition of alluvium, they must, on the whole, carry away annually a large quantity of earth. The fixed valleys of the great rivers are of very variable width, generally bounded by steep high banks; they are called *Khádar,* the adjoining high land being known as *Bhángar.* The deep, low-water, channel of the river oscillates within the *Khádar,* or river-plain; the whole of this being liable to inundation from the floods, and to constant erosion and re-formation by the action of the current. *Khádar-mati* is very nearly the native equivalent for 'alluvial land.' But though there is always a large total area of true alluvial land in the *Khádars* of the great rivers, it is possible that, on the whole, these *Khádars* are undergoing denudation, that the river-bed is deepening, and that the new alluvial land formed by its changes of position may be progressively lower than the older patches removed by the same process. It has not yet been defined how much, or if any portion, of the eastern districts come within the sub-deltaic conditions that prevail in the Lower Provinces, where the river-action is broadly formative. The whole of the province of Oude would come under one or other of these descriptive terms—*Bhángar* or *Khádar* land.

Whether the great rivers are raising or lowering their Khádars.—The question whether the great rivers have at present a tendency to deepen or to raise their channels is one of much importance in relation to engineering works, and of great interest to the geologist. Within deltaic regions, where the rivers are essentially formative. the process is sufficiently understood: the bed and banks of the main channel are raised, till the contrast of level determines a gradual set of the water to lower ground through some minor distributary; the new channel is at first scoured out to the capacity of the main channel, when the raising action recommences. Within the narrow river-plain of the *Khádar*, there might be no general feature to betray which process is in force. The river would oscillate pretty much alike in either case, removing and replacing the patches of alluvial land. Still it seems likely that careful enquiry among the natives cultivating the *Khádars* would elicit some grounds for judgment: as, if any very old patches of alluvium were no longer inundated by the highest flood, one might infer that the river had lowered its channel. The *á priori* conditions may be stated briefly thus: Whether a river is cutting or depositing depends, of course, upon its velocity and upon the charge of solid matter, wholly or partially suspended in it. As regards the first condition, it can be broadly stated that the slope (and hence the velocity) within the *Khádars* is everywhere much above that at which silt-carrying rivers become on a large scale depositing rivers: at Kánhpúr the fall is nineteen inches per mile, at Alláhábád thirteen; while in the sub-deltaic region at Pátna and Rájmáhál it is only six inches; and in the Delta proper it lowers to three inches.* It is moreover certain that for eight or nine months of the year, the great rivers rush from their gorges in the mountains as torrents of clear water, or only, in the hot months, discoloured by fine glacial mud; immediately upon entering the *Khádar*, however, the water becomes more or less charged with silt and continues so throughout its course. For these months then the river must be denuding its channel. During the flood season, on the contrary, the water issuing from the mountains is highly charged with detritus; which is, to some extent at least, gradually deposited as the slope of the channel becomes lowered in the *Khádar*. It would be difficult to conjecture to what distances within the plains coarse shingle and gravel might be rolled along by the scour of the current in extreme floods during successive seasons. Large stones not being found in the bed of the river in the dry season may not be a safe indication of the case; as it is conceivable that they should always be buried under lighter deposits as the flood subsided. Whether or not the rivers are able, even with the assistance of the clear water for eight months of the year, to carry out of the *Khádar* all that they carry into it in the flood season, cannot be determined without careful observation; but from all the considerations mentioned, it would seem likely that throughout the greater part of the *Khádar* the balance is in favor of erosion. Any tendency of the Ganges and Jamna to lower or to raise their bed at the mouth of their gorges ought to be discoverable from the effect on the canal-heads at Hardwár and Fyzábád.

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* These figures are quoted from Mr. Fergusson's paper in the Quart. Jour. Geol. Soc., Lond., Vol. XIX, 1863.

Continued observations on the silt in the water, uniformly conducted at distant places, as at Fatehgarh, Kanhpúr, and Alláhábád, might indicate whether erosion or deposition is taking place within the Khádar region. But the most satisfactory test would be, continued registration of the rise and fall of the water on permanently fixed gauges, to be checked by an annual exact measurement of the low-water river-section at each gauge.

Bhábar and Tarai land.—Independently of such tracts on the eastern borders of the province as come within the sub-deltaic region of the great rivers, there is a considerable stretch of country where the drainage is formative. The minor streams from the outer skirts of the mountains do not run on into the plains in deep channels cut through deposits of earlier times; they flow, at least for many miles, in broad shallow and ever-shifting beds formed of materials brought down by themselves. The load of shingle, gravel, sand, and earth washed into these torrents by the heavy rainfall from the precipitous slopes of the Sivâlik hills, formed of soft conglomerates, sandstones, and clays, is far more than the current can carry into the main rivers. It is possible, too, as has just been discussed, that something of the same kind takes place in the upper reaches of these rivers themselves. There is thus, along the northern margin of the plains, a broad belt of ground the formation of which is strictly 'recent.' The portion of it next the hills, having a steeper slope than the rest, is chiefly composed of shingle and gravel with a filling in of sand and earth. This is the forest-bearing zone known as the *bhábar*. Except in the rainy season, it is devoid of water; streams of considerable volume soon sinking into the porous ground, to reappear (at least in part) along the lower fringe of the coarse deposits. This second zone, though having, on the whole, a considerable slope, greater than the general slope of the plains, is thus made watery and swampy; it is well known as the *tarai*. West of the Ganges this formative process is specially active owing to the greater development here of the soft Upper Sivâlik rocks, which are the most abundant source of detritus. Some years ago, excavations in connection with the Eastern Jamna Canal brought to light the ruins of an ancient town. The tarai in the Jamna-Ganges *Doab* is scarcely a noticeable feature, owing probably to the good natural drainage; the watershed being here 400 feet above the Ganges at Hardwár. Eastwards from the Ganges the *tarai* becomes more and more distinct. In the same direction remnants of an ancient *bhábar* deposit become frequent and of increasing elevation, till in the far east, at the base of the Sikim Himalaya, they stand at 1,000 feet over the actual torrents. To the south of the plains some analogous cases of recent deposits may be found, but they are altogether insignificant; the larger rivers there also running in channels which they do not overflow to any extent.

The phenomena under notice have been only incidentally examined, so that the sketch here given is very incomplete and open to correction.

Age of the bhángar land.—It having been shown that the great mass of the plains-deposits belongs to a bygone period of formation, it devolves upon the geologist to ascertain the age and nature of the process. Very little progress has as yet been made to that end; the systematic study of the question not having been taken up. Some have maintained that the deposits are marine or estuarine; others, as seems most likely, that they are, at least to any observed depth, purely fluviatile, by a process like what is now going on in the Bengal Provinces. No trace of marine organisms has been found in them. But some bones of terrestrial mammalia were got in a hard bed of calcareous gravel in the bed of the Jamna near Etáwá; and which seem to belong to species or varieties now extinct; so that those deposits will probably take rank among the later Tertiaries. From observations made in sinking wells along the line of railway, one of the engineers has stated the general section of the Ganges-Jamna Doab south of Aligarh to be—loam 35 feet, blue silt 30 feet, strong lay 20 feet, resting on a water-bed of reddish sand, from which the water rises some 30 feet

The bed of clay slopes from north to south at about two feet in the mile, the surface sloping about eighteen inches in the mile. The water obtained from the blue silt is always more or less saline. The only deep section of the plains-deposits is from the boring for an artesian well at Ambála. This position, a little to the west of the Ganges-Indus watershed, is on the zone of recent deposits; the river channels are all superficial, and become lost in the desert country to the south. There is nothing in the section of the boring to mark a change from these surface deposits to others of an older period. None could, indeed, have been expected, as it is only on an extended horizontal section that a plain of denudation, such as that of the present Ganges-Jamna Doab, could be detected between any older beds and perfectly similar materials recently overlaid upon them. There is moreover no presumption that any such break exists in the plains-deposits west of the main watershed, or at least at that watershed. A single boring, too, can tell little or nothing of the arrangement of the strata. The depth reached was 455 feet, or 450 feet above the sea-level. Frequent alternations of clay and sand were passed through. At 286 to 296, and 400 to 417 feet, coarse gravel and large stones were found; strong beds of clay occurring again beneath.

Kalar-lands.—The presence of alkaline salts to a very deleterious extent in the subsurface water, and their appearance as an efflorescence in many parts of the country, has been an object of anxious enquiry in Upper India for many years back; especially as it seems on the increase, and most so in connection with irrigation. The efflorescence consists principally of sulphate, carbonate and chloride of sodium; more rarely nitrate; and occasionally with potassium as base. The crude salt with its earthy admixture is called *Kalar* (Kullur). The cultivators also speak of it as *úsar* and *reh.* But the former word is said properly to mean negatively sterile soil; and *reh* is said to be properly applied to the carbonate of sodium (or natron). Several conjectures have been made as to the origin of the *Kalar*: 1, that it is an aboriginal ingredient of the soil; 2, that it is continually being elaborated from the soil by the action of water; 3, that it is brought up by water from saline deposits at some depth from the surface; 4, that it is very largely and to an indefinite degree due to accumulation by evaporation from lodgement of inundation waters. It is not likely that any of these is the exclusive cause; and it is most important to determine in what degree each of them may operate, with a view to determining the remedy to be applied in each case. The third supposition, which would be the most unfavorable of all, may be set aside. There are some spots on the plains of Upper India, as at Bhartpúr, where deep brine-wells are worked; but the ground near them is not *Kalar*-land; and, on the other hand, throughout the tracts of Kalar-land the water of the deep wells is sweet, holding as little as, or even less saline matter than, the water of the great rivers. It is of course known that the *Kalar* salts are in the main the product of the decomposition of silicious minerals by atmospheric and other surface conditions. But the ingredients of alluvial deposits are entirely made up of mineral detritus that has already undergone the principal phase of this soil-producing action; and its further decomposition would be very slow indeed. Whatever opinion may be maintained regarding very ancient *Kalar*-land, all the evidence upon the recent formation of these salts goes to prove that it is due to accumulation by evaporation in water-logged land; and it is a necessary corollary from this that water-logging from river or canal inundation must immensely increase the rapidity of its growth. Flooding from rain would be limited to the salt-resources of the ground affected, or of such local drainage as it received; whereas river or canal inundation would be an inexhaustible source of importation of these salts. Various remedies have been suggested for this most serious evil: the cultivation of plants, such as the barilla plant, which assimilates a large amount of some of these salts; the application of suitable mineral manures, so as to facilitate the utilization of these salts by ordinary crops; the application of efficient drainage. If one had only a definite amount of Kalar to deal with, as would be the case supposing it to be of purely local origin, the application of the first two methods might be sufficient. But with an inexhaustible and ever renewed source of the salt, such as is supplied by river and canal water (both being drainage water), it seems evident that efficient drainage is the only sufficient remedy.

II.—The Himalayan region.

Physical and Geological divisions.—In Kumáon and Garhwál the boundary of the Province extends up to the great snowy range, the frontier of Tibet. West of the Ganges, the District of Dehra-Dún (including Jaonsár) comprises only a small portion of the Lower Himalaya. The mountain-area presents three well-marked physical zones. There is a narrow fringe of low hills, which, from their analogy to similar ridges in other countries named after the range to which they are subordinate, have been called the Sub-Himalayan range. North of these the mountains rise abruptly to an elevation of 6,000 to 7,000 feet; and from here there is a broad belt, some fifty miles wide, of ridges having this elevation, or but very little over it, up to the base of the great snowy range. This middle zone has been designated the Lower Himalayan region. The geology of the hills has as yet been only cursorily examined. The rocks that appear within the limits of this province may be noticed under three heads: 1st, the Sub-Himalayan series, corresponding in distribution, at least in its upper groups, with the lower hills designated by that name; 2nd, a limestone and slate series, occurring very constantly in a belt of varying width along the margin of the Lower Himalayas, as at Naini Tál; and 3rd, a metamorphic series with granitic protrusions, forming the rest of the Lower Himalayan region, and also the line of snowy peaks; close upon the northern flanks of which, beyond the frontier, there rest the Palæozoic and Secondary rocks of Tibet.

The Sub-Himalayan Series.—The youngest of these divisions, the Sub-Himalayan series, includes a wide range of the Tertiary period; from the nummulitics up to the Miocene Sivaliks; and these are closely connected with the Pliocene deposits of the plains. In this series three well marked physical stages have been described. In point of elevation the order of sequence of these has been reversed—the oldest being highest and the youngest lowest, in their respective zones. This has not taken place by inversion; nor yet (it has been argued) by upheaval in steps, through faulting. Appearances are best explained by the supposition, that during successive periods of elevation an irregular scarped line of erosion was weathered out along the newly raised strata (like the present cliffed face of the Sivalik hills); and that against this, as boundary, the newer groups of deposits were accumulated, just as we see the *bhábur* slopes of the present day. As would result from such a process, the oldest group has been most elevated and longest exposed, and so has suffered most from denudation. Only remnants of it are left along the margin and on the flanks of the higher hills.

The Subáthu group.—The typical area in which all the sub-divisions of the lowest group are seen lies out of the North-West Provinces, to west of the Jamna. The hill stations of Kusaoli, Dagshai, and Subáthu are on these rocks, which take their name from the last of these places. The base of the group consists of brown clays with limestones and fine sandstones, passing up into thick red clays and strong sandstones. The age of the lower portion is well characterized by abundant *nummulitic* fossils. Only a very small remnant of these beds has yet been observed in these provinces. It occurs on a gap of the ridge bounding the Eastern Dún, close above Rikikés, and just north of the village of Bone. The hills of Kumáon and Garhwál have been only cursorily examined, and other outliers of this group may yet be found.

The Náhan group.—The middle group of the series is largely developed in the hills immediately at the base of the mountain range, as spurs of which they might be hastily described; but their distinctness as a range is well marked by a line of low gaps and open longitudinal valleys along the geological boundary, the drainage passing through the range by narrow transverse gorges. These features may be well seen along the Western Dún under Masúri. In the Eastern Dún, from Rajpúr to the Ganges, this flanking range has been removed; but east of the Ganges it appears again in great force, continuing so up to the Nepal frontier. The strata are well exposed along both roads up to Naini Tál. They consist principally of massive gray sandstone (very like the molasse of Switzerland), with subordinate bands of clay. The small nests of lignite found at many places in the sandstone have more than once given rise to exaggerated hopes, and even to confident statements, as to the existence of coal. The fine hæmatite iron-ore of Dechouri near Kálidúngi is only a local concentration of the iron oxide which occurs so freely disseminated as an ingredient of the clays. This middle member of the series has been called the Náhan group, from the chief town of Sirmúr.

The Sivalik group.—The youngest member of the Sub-Himalayan series is the Sivalik group, so called from the name given to the outermost range of hills by Colonel Sir Proby Cautley, who found in those rocks the splendid collection of vertebrate fossils, partially described by Dr. H. Falconer in the Fauna Sivalensis. These hills are much lower than those of the middle group, from which they are generally separated by the broad longitudinal valleys known as the *dúns;* which are structural features, not mere valleys of denudation. The form of disturbance of the strata is very regular: broad 'normal' anticlinal flexures, the axis-plane sloping towards the mountains. The Sivalik hills have been weathered out along the axis of the flexures; and the *dúns* lie on the flat northern slope The original 'Sivalik Hills' are that well-defined portion of the range between the Ganges and the Jamna separating the Dehra-Dún from the plains. From a short distance east of the Ganges the range is broken and scarcely recognisable, having probably been denuded off and covered up, if indeed it had ever been so prominent as to the west. The *bhábar* deposits here often reach up to the base of the inner range of the middle group of rocks. The Pátli Dún is an irregular valley of denudation in these hills of the Náhan group. The lower part of the Sivalik group is very like the Náhan group in composition, save that the sandstone is softer and fresher. At top there is a great thickness of conglomerate, both earthy and sandy. The physical separation between the Sivalik and the Náhan group has recently been clearly made out; but the distinction was unfortunately not observed in the collection or the description of the great series of fossils formerly procured from this region. The vast majority, if not all, of the large mammalian remains were obtained from the younger group; some vertebrate fossils were found in the Náhan rocks, but they were in great part lost or were mixed with those from the Sivaliks: a very interesting point—the comparison of the two faunas—was thus missed.

The limestone and slate series.—The second rock-system to be noticed consists of an unknown thickness of slates, limestones, and sandstones, forming the first range of the mountains from end to end. The stations of Chakráta, Masúri, and Naini Tál are on those rocks. The strata are greatly contorted, although preserving a strike approximately parallel to the mountain range; and the relations of the several bands of rock can now be only vaguely suggested. From the more regular sections in the hills west of the Jamna the series has been roughly divided, in descending order, into—The Krol limestone; the Infra-Krol slaty shale (often carbonaceous); the Blini limestone and conglomerate; the Infra-Blini slates. It is the Krol limestone that determines the picturesque outline of the outer ranges, as at Naini Tál, compared with that of the great mass of the Lower Himalayan region. The Blini limestone has also been traced eastward, along the outer flanks of the mountains, to as far as under Naini Tál. The Krol group has been asserted to be of triassic age; but the only fossils certainly known to have been procured from these rocks within these provinces were some indeterminate casts of bivalves from a band of limestone in the gorge of the Tál river, at the east end of the Dehra-Dún. The lead-mines of Sirmúr and those near Subáthu are in this series of rocks. Trappean intrusions occur at many places in them.

The metamorphic series.—At many places, as on the Simla section, there is a complete transition from the slate series into the crystalline schist series, through a graduated metamorphism. Elsewhere the passage is abrupt, as in the valley north of Naini Tál, where the junction is complicated by profuse trappean intrusion. The great mass of the lower Himalayan region, and also of the snowy range, is composed of crystalline schists, gneiss, and granite. There is a large mass of intrusive granite near Almora. Copper ores occur at many places, and are worked by the natives. They have not been favorably reported on by European mineral-viewers. There are also many fine bands of rich iron ore; but the inaccessibility of the ground prevents their being extensively used. Impure graphite is found in several places.

III.—The Peninsular region.

Although the rock-area south of the plains and within the North-Western Provinces is very small, it forms an extended line; and thus it includes representatives of the principal rock-series of Hindustan, excepting only the Deccan trap formation and the cretaceous rocks below it. There are thus to be noticed—

The coal-bearing series.
The Vindhyan series.
The slate series.
The schist and gneiss series.

The coal-bearing series.—The great plant-bearing series of rocks, so widely scattered over India, has been divided in different basins into a number of well-marked groups. But the characters of many of those sub-divisions, or their equivalence in time, do not exactly correspond from one basin to another, so that it is impossible as yet to adopt a scale of groups applicable throughout. The two bottom groups of the series are the most widely distributed and the most constant in character. The Talchírs, the lowest group, is of special interest as exhibiting undoubted glacial action in very ancient rocks (probably Palæozoic), and in what is now an intertropical latitude. The most characteristic bed of this group is a fine greenish-gray silt, in which there frequently occur huge boulders of rock, sometimes rounded, and sometimes, in the same spot, quite angular, occasionally polished and deeply grooved by friction; just as is at present only known to occur in glacial deposits. It is not possible at present to conjecture to what conditions—whether to great elevation, or to change of climate from cosmical causes—these phenomena were due. In most of the fields throughout India the coal-measures are confined to the Barakár group, which is largely made up of coarse felspathic sandstones.

In British Singrowli, the southern extremity of the Mirzapúr District, there are about forty square miles of the Talchír group exposed; and about twenty more overlaid by the Barakárs. From the Kota mine in Singrowli all the coal was procured, which used in old times to be carried on pack-bullocks for forty miles, across the Vindhyan plateau, to Mirzapúr, for the steamers on the Ganges. The sandstone forming the small plateau over the coal-measures at Kota probably belongs to one of the upper groups of the series. This is the only patch of this series of rocks within the North-Western Provinces. It is the eastern extremity of the great central basin of South Ríwah.

The Vindhyan series: its characters.—The base of the plant-bearing series is separated all over India by total unconformity, involving a great break in time, from the next preceding formation, which is known as the Vindhyan series. The precise range of this series has not yet been fixed. The rocks to which the name was first given, or rather adopted from the old geographical name, are the strong fine sandstones forming a very long range of cliffs along the north side of the Narbadá valley from Hosungabad to Jabalpúr, and continuous thence along the north of the Sôn valley to Sasseram in Behar. As the sandstones recede from this line of cliffs, they become steadily split up by thick bands of shales, with limestones, and so necessitating a division into three principal groups, as Bhanrer, Ríwah, and Kaimur, forming the original Vindhyan series. In the Sôn valley the sandstone cliff is weathered back to the north of its line in the Narbadá country; thus exposing older beds, underlying the Kaimur sandstone. These consist of limestones, fine flaggy sandstones and shales, with strong bands of very peculiar porcellanic and trappoid beds; the whole forming a series of local groups. Beds of exactly the same description as those of the Són Valley appear again along the north edge of the Vindhyan basin; and here also they stop out against the gneissic rocks of lower Bandélkand, and so are entirely overlapped by the Kaimur sandstone. They were here first described as the Semri series, but are now properly merged in the Sôn series. As these strata present throughout steady parallelism with the Vindhyan beds above them, both occupying the same basin, being alike affected by local disturbance, and alike free from any symptoms of metamorphism (except the conversion of the sandstone into quartzite in certain positions of disturbance), the name Vindhyan has been extended to the whole series, with only the distinction of Upper for all the original Vindhyans and of Lower for the Sôn series. On the north side of the gneissic area of lower Bandelkand, about Gwalior, there is a group of rocks resting, just as the upper Vindhyans themselves do, upon an old surface of the gneiss; they have scarcely undergone any more disturbance or metamorphism than the Vindhyans; but the Kaimur conglomerate rests unconformably upon an ancient surface of erosion of these rocks, and is largely made up of their débris. There is, however, at least one marked character common to the Gwaliors and the lower Vindhyans—the peculiar porcellanic and porphyritoid beds occur in both; and it would be by no means improbable to suppose that the two are in part cotemporaneous deposits. There are also marked differences between them; the Gwaliors are highly ferruginous and include some strong sheets of cotemporaneous basic trap. These new characters, on the other hand, suggest another link in the descending series of formations: recrossing the same gneiss, to the south, we find in the Bijáwar country a new group of rocks, still again resting flatly upon an eroded surface of the gneiss, only partially disturbed and showing only incipient metamorphism, but upon which the original lower Vindhyans rest unconformably. Cotemporaneous trap and highly ferruginous deposits are marked features of this Bijawar group; and it would not be extravagant to assume that it is, in part, cotemporaneous with the Gwalior group. Again, in the Són Valley, the lower Vindhyans rest with extreme unconformity upon beds that have been thought to represent those of Bijáwar, and which have become highly metamorphic and associated with gneissic rocks. We thus finally arrive at the suggestion of a younger and an older gneissic series; without finding, below the Vindhyans proper, a clearly marked physical break applicable generally over even so small a geological field as the Indian Peninsula.

The stratigraphical difficulties observed in the preceding paragraph might be removed by the aid of fossils; but to the great disappointment of geologists in India, the Vindhyans have as yet yielded no organic remains, although the undisturbed and unaltered strata composing them, often covered with fine ripple marking, continually tempt one with the hope of successful search. Some forms supposed to be corals were found by Mr. Hacket in a limestone of the Gwalior series.

Besides producing in abundance building stone of first rate quality and limestone, the Vindhyans are only remarkable as containing diamonds. The mines near Pannáh are now more worked than any others in India. The gem is, of course, found in the diluvial deposits; but the diggings most prized are in the Riwah group of the Vindhyan series. Although, however, this group has a very wide range, diamonds are not known to occur in it beyond a very limited tract in the State of Pannah. This fact and other observations have suggested that the diamond was not originally formed in the Riwah group; but rather in some peculiar contact-rocks at the base of the lower Vindhyan, or Sôn, series, and well exposed in the sections close to the north of Pannah.

Its distribution.—The Karamnásá, forming the eastern boundary of the North-Western Provinces, flows from the eastern extremity of the Vindhyan plateau. From here to Futehpúr Sikri (which stands upon a ridge of Bhanrer sandstone), south of Agra, the north scarp of the Vindhyans corresponds approximately with the south boundary of the provinces; the native states of lower Bandelkund being intricately interwoven with the districts of Banda, Lalatpúr, and Jhansi. Only, on the east, the Mirzapúr district stretches southward across the Vindhyan plateau, here formed of the Kaimur group, and across the Sôn valley, where there is a full section of the lower Vindhyan, or Sôn, series. The northern outcrop of this same series is exposed in the Banda district, about Kirwi. The Gwalior series just touches the border of the province in the Etáwah district.

The slate series.—In discussing the range of the Vindhyan series, the Bijáwar formation was mentioned as showing incipient metamorphic action. It is made up of hornstone-breccias, quartzite-sandstone, cherty limestones, ferruginous sub-schistose slaty shales, and thick sheets of basic trap-rock. The districts of Banda and Lalatpúr just touch upon the original area of these rocks in Bijáwar. In the Mirzapúr district, in the hills south of the Sôn, similar rocks occur, in a state of high contortion, and connected on the south with a broad band of clay-slates, which are in turn intimately associated with crystalline schists and gneiss.

The schist and gneiss series.—The wide bay formed by the Vindhyan scarp between Gwalior on the north-west and Kirwi on the south-east is occupied by highly metamorphic rocks,—coarse porphyritoid gneiss and crystalline schists. In the districts of Jhansi and Lalatpúr these rocks appear freely; but to the north-east, in the districts of Jaloun, Hamirpúr, and Banda, outcrops become more and more scarce as the rock disappears under the plains deposits. The strike of the foliation and of the bedding, where observable, is generally east and west. Greenstone dykes are very abundant, with a prevailing north-west-south-east direction. None of these dykes pass into any of the overlying sedimentary rocks, and are therefore presumably of older date. The most striking feature of this area is the prevalence of great quartz-reefs, standing up in great wall-like ridges, sometimes more than three hundred feet high, many yards wide, and running quite straight for several miles continuously, or with intervals appearing again on the same strike. They have a prevailing north-easterly run, but exceptions are frequent. These also are certainly older than the Bijáwar formation, and also apparently older than the trap dykes. It has been thought that gold should be found in or about these great quartz-reefs; but there is no trace or tradition of its occurrence. According to some theories, this would be accounted for by the extreme antiquity of these reefs and of the enclosing gneiss.

The gneiss at the southern point of the Mirzapúr district in Singrowli belongs to the great metamorphic area of Behar and Bengal. Here also massive porphyritic and granitoid gneiss is the predominant rock, with subordinate bands of hornblende schist. There is a strong band of fine Corundum in it near the village of Pipra. Bands of crystalline dolomite and limestone are also frequent in this gneiss; whereas none whatever has been observed in the gneiss of Bandelkund.

H. B. MEDLICOTT.

September 1872.

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THE SOCIETY.

January 10th, 1872.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1874. **[February.**

Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1873.

For the first time since the institution of the Geological Survey of India, it devolves upon an Officiating Superintendent to draw up the Annual Progress Report. Dr. Oldham, who may be said to have founded the survey, was compelled for the first time, after more than twenty-two years of continuous service, to take sick-leave to Europe early in April. For many months previously it had been strenuously urged upon him that rest and change of climate were necessary for his health. Even when he did leave India, it was to work hard in putting our collections into order in the Exhibition at Vienna; and the high merit officially awarded to those collections is largely due to his personal exertions on the spot as well as in India. The Superintendent's absence being only for a season, no change of method has been made or proposed, as unless permanently adopted such would only be mischievous. This report will therefore be as brief as possible.

It should be remembered that the progress reported on relates to the work accomplished during the field-season ending in April, May, or June, according to position, and brought into form during the recess for the monsoon; a preliminary notice being added of the distribution of the field work for the season opening in October and November.

I am unfortunate in having to chronicle a season of particularly slack work. Besides the absence of the usual number of the staff on sick-leave, several causes supervened to disturb what must be considered the normal work of the Survey. These interruptions were more or less unavoidable, and are to be taken as work done, under which head I have here placed them. In some cases at least the advantages gained, special or general, will compensate for any loss to our yearly tale of ground surveyed.

For the last half of the year six out of our small staff were absent. Mr. Blanford has been in Europe for the whole twelve months. Hard work in Persia made it necessary for him to take sick-leave; but he has been busily engaged in working out the very valuable zoological collections he took home with him from those little explored regions. He has also been mindful of Indian Geology in giving to the Society of Arts an excellent abstract of our work as illustrating the mineral resources of India, besides several papers of scientific interest read to the Geological Society and to the British Association. Mr. Fedden has been absent on sick-leave for the entire year. After a long struggle with an exhausting illness, Dr. Waagen was compelled to take sick-leave at the end of December 1872. Till the day of his departure he laboured at the description of the jurassic fossils of Kach, leaving the first portion of the work ready for publication, and a quantity of manuscript and plates in an advanced state of preparation. The Survey was especially fortunate in securing the services of Dr. Waagen for this work, as he had already achieved a sound reputation by his researches in formations of corresponding age in Europe. We have to lament that the tidings of his health are very unfavorable. As already noticed, Dr. Oldham had to go on sick-leave early in April. We may, perhaps, hope that improved health, and relief from the interruptions and preoccupation inseparable from the duty of directing widely scattered operations and correspondence, may give him leisure to mature the long expected introduction to the geology of India. The absence of Dr. Stoliczka, although depriving us for a time of our palæontological oracle, is not to be regretted when we consider the service he is engaged on. Every arrangement had been made for him to attend the gathering at Vienna as the rightful exhibitor of the most interesting part of our collections, and where there was so much to attract him, but he eagerly gave it all up to seize the opportunity of visiting a new field of research as naturalist with the Mission to Yarkand. In spite of the great suffering he endured in crossing the Korakorum range at so late a season, he has already contributed an interesting sketch of his observations of that ground. Before leaving, Dr. Stoliczka had just completed the publication in the Palæontologia Indica of his highly valued work on the Cretaceous Fauna of Southern India. The remaining absentee is unfortunately to be recorded as permanent: Mr. J. Willson, after his brief connection with the Survey, finding that the duties were more than his health was able for, transferred his services to the Educational Department, in March. The loss thus sustained by the Survey of an officer whose thorough training in science gave promise of high efficiency, is not to be made good; the Government having decided that the pay of this appointment is to be devoted to the experimental institution of native apprentices.

Although the staff of the Survey is nominally divided into three parties, under Deputy Superintendents corresponding with the three chief Presidencies, it has never been found convenient to adhere closely to this arrangement. Those who have studied certain formations must follow them out irrespectively of fiscal boundaries; and in so large a country, where communication is often difficult, it is commonly most convenient that each geologist should communicate independently with head-quarters in Calcutta. The work may therefore be most intelligibly noticed with some attempt at natural order, commencing with the formations to which our coal-measures belong.

In the south, Mr. King accomplished a very satisfactory season's work in the region of the lower Godavari. He revisited the Singareni coal-field, which he had discovered and described in the preceding season. Numerous trial borings had meanwhile been put down by the Nizam's officers, and a considerable amount of coal proved, although the seam was not found to be continuous throughout. The Beddadanole coal-field was fully examined; and although no outcrop was discovered, there is considerable hope tha coal exists. Mr. King gave full directions for prosecuting the search by borings, and orders have been given by the Madras Government for their being carried out. This field is not, like the Singareni field, circumscribed within very narrow limits by the older rocks. The actual area of measures exposed is not larger than that of Singareni; but the rocks are seen to pass beneath an extensive spread of a younger formation, and there is at least a chance of there being a considerable field, much of it in British territory. In this region we had hitherto only discriminated three members of this great rock-series; namely, the Talchirs, the Barakars, and the Kamthi sandstones, which Mr. Blanford had followed down the Godavari and Pranhita valleys from Chanda and Nagpúr, where he had, from the evidence of the fossil plants, ranked them in the Damuda horizon. From other fossil evidence, found in this confused upper sandstone series of the Godavari basin, it has long been considered that in part at least it represents formations younger than the reputed age of the Damudas. The obscurity regarding the correlation of this whole series of rocks with established formations has been owing to the failure hitherto to link any important portion of it with beds containing a distinctive marine fauna. Such a connection has long since been made for the Rajmahal group, through the Kach deposits; but the connection of the Rajmahal group itself in its typical area with the main rock-series is very uncertain. Mr. King has at last been so fortunate as to hit upon what may yield a clue to our puzzle—a fossiliferous zone of marine beds at Ragavapuram, thirty miles due west of Rajamandri, well intercalated with the upper sandstones, continuous with those overlying the Beddadanole coal-measures. In the same region, at Innaparaz Katapili, thirty miles north-north-east of Coconada, he also found fossils, in some detached sandstone beds along the northern margin of the Godavari delta. These latter fossils have been recognised by Dr. Stoliczka as on the horizon of his Oomia zone (uppermost jurassic) in the Kach series, the same which had long since been assimilated to the Rajmahal group. The Ragavapuram fossils did not reach in time for Dr. Stoliczka to examine them. They are at least specifically different from those of Innaparaz, and underlie a rock which Mr. King conjectures to represent that of the outliers. The facies of them, so far as a non-expert can pronounce, is jurassic. Above all these rocks, and underlying the trap, Mr. King discriminates a belt of sands with a thin limestone, characteristically similar to the Lameta or infra-trappean group of the Central Provinces, and which he conjectures to be cretaceous; the fossils in the limestone being distinct from those of the well-known Pangadi inter-trappean beds close by. The working out of all these suggestions is of the greatest importance to the geological history of India.

In this connection notice may appropriately be taken of a document quite recently published and circulated by the Government of Madras. It consists of a large-scale map, in divers colours, of a small area on the Kistna river about fifty miles south-by-east of the Singareni coal-field; with an explanatory text by Colonel Applegath, in which the old assertions are repeated regarding his discovery of coal there many years ago, with the addition that, having recently visited the coal-fields of the upper Damuda valley, he is in a position to assert the geological identity of the formations. It only needed this to complete the anomaly. Whatever possibility there might be of a coal being found in these rocks, quite distinct from that of the Indian coal-measures and unobserved by more recent explorers, it is really not within the range of possibility that several geologists of experience should so utterly confound rocks with which they are perfectly familiar. The ground referred to is the northern extremity of a large geological basin, of which a map with detailed description was published during last year in the Memoirs of the Survey. Working from the south, Messrs. King and Foote had no hesitation whatever in identifying these rocks on the Kistna as part of the connected series of Kadapah and Karnúl rocks, in the examination of which they had been engaged for several consecutive seasons. After the completion of that work Mr. King moved northwards, and found no difficulty whatever in recognizing the true coal-bearing series in the Singareni field, for the exploration of which by borings he gave indications which have proved successful. An account of this was also published during last year. Still we find the false prophets apparently in as great favor as ever with the authorities in Madras. Comment on such proceedings would be superfluous.

More to the north, in the Godavari basin, Mr. Hughes was engaged for the whole season in the Wardha coal-field; but frequent interruptions greatly retarded his progress towards completing the examination of the field. Several weeks were taken up in connection with Mr. Bauerman's deputation to examine the iron-deposits. Time was also spent in interviews with the mining officers of His Highness the Nizam, and in selecting sites for borings at Warora and Pisgaon. The chief independent result of the season was the demarcation of the small detached coal-field near Chimur, which may yet be of importance in connection with the iron ores of the neighbourhood. In examining the zamia-bearing zone on the south-west margin of the field, Mr. Hughes found a small coal-seam in it at Balanpur, which curiously repeats the characters of the seams on the same horizon in the Jabalpur group of the Narbada region. In the Wardha field two pits have been sunk to the coal, one at Warora in the Central Provinces, and one at Pisgaon in East Berar.

Mr. Medlicott took up his work in the Satpura, with the understanding that he was to carry out the examination of the formations so closely connected with the coal-measures there, and by which these are concealed; while at the same time he was to afford geological guidance for the borings he had recommended in the Narbada valley. The executive management of these was entrusted by the local Government to Mr. Collin, a mining engineer, or coal-viewer, sent out from England for the coal exploration in the Central Provinces. Both the personal and material provision for these trials proving utterly inadequate, Mr. Medlicott was afterwards called upon to supervise the execution of the work. Thus the geological investigation was stopped, in the vain hope of preventing the inevitable collapse, under existing arrangements, of the experimental work. The work Mr. Collin had executed was so bad that it had to be abandoned; while Mr. Medlicott, owing to this fruitless interruption, was only able to complete his examination of the lower Dudhi valley, with a view to fixing the sites for the borings there. Late in March the borings at Gadarwara and Sukakheri were recommenced under the immediate charge of Mr. Stewart, a very intelligent and trustworthy employé on the Great Indian Peninsula Railway, whose services were obligingly placed at the disposal of Government by the Agent, and under the supervision of Mr. Cooke, the Executive Engineer at Narsingpur.

These trials were undertaken upon the fully discussed possibility and a reasonable probability that the Satpura coal-measures might here extend from the Sitariva field beneath the alluvial plain. No depth could be assigned for these covering deposits. From 200 to 500 feet was given as the probable range. Considering the delays and difficulties to be contended with, the progress up to date must be taken as very creditable to those in charge of the work. Insufficient and defective piping has been throughout the chief difficulty. The boring at Gadarwara had to be stopped at the end of October, as the piping could not be driven beyond 226 feet, and there were no pipes of smaller diameter to sink within those that had stuck. The rods were put down to 251 feet, still in alluvial ground; but the hole could not be kept clear without the piping. At Sukakheri work was in progress at the close of the year, the piping having reached a depth of 330 feet, still in alluvial clay. Thus, of course, we as yet know nothing as to what rock underlies these deposits; the great thickness of which will prove a great impediment to mining enterprise should coal be found beneath them.

In view of the great extension of boring operations in all parts of India, it is to be regretted that there is still much misapprehension regarding the nature of the work, and consequently want of system and concert in the management. Next to the important object of these operations, the work of the Geological Survey is the chief sufferer from this defect. Among homogeneously civilized communities it is duly recognised that boring is a branch of engineering; that although the geologist might give the safest indications for the position and prospects of a boring, he would probably make a bungling attempt at executing the work. The mining engineer is supposed to, but very rarely does, combine these two branches of knowledge so radically distinct. In all new and intricate cases the greatest safety lies in the combined action of independent experts. This combination might no doubt be obtained in India as it commonly is in Europe, both elements being present. Such undertakings are, however, new to this country; and we have not got beyond the *primâ facie* point of view: because the majority of engineers will declare that they know nothing about boring, and the geologist cannot disown his connection with the business, it is assumed that the latter must be the best man for the whole job. The mistake is very similar to insisting upon a zoologist or a metaphysician performing the Cæsarean operation because a number of surgeons standing by chose to excuse themselves on the plea that they had never seen the thing done. No doubt a man of intelligence and education can always make some useful attempt at the supervision of mere skilled labour; and I have no doubt that Mr. Stewart would acknowledge his obligations in this way to Mr. Medlicott; but it is a fact that this geologist, when he was ordered to take charge of the borings he had recommended at Gadarwara, had only once before seen a boring in a casual way, and did not know the difference between a crab-winch and a jack-rolo, between a wrench and a spanner. I cannot but think that such important operations, depending entirely upon mechanical ingenuity and resources, should be under proper professional control and responsibility, and also that this should be forthcoming in some branch or other of the Department of Public Works.

In the Damuda basin Mr. J. Willson spent the season in retracing the lines of the Karanpura coal-fields on the newly issued maps of the Hazáribágh district.

Mr. Hacket was incidentally engaged upon these same formations, in adding to our collection of fossil plants from the Jabalpur group; but his chief occupation for the season was to trace the boundaries of the Vindhyan and older rocks on the new maps along the northern side of the Narbada valley in the Jabalpur, Narsingpur, and Hosungabad districts, and at the same time to add to our collections from the ossiferous valley deposits. Mr. Hacket filled in a large area.

In the same region, more to the north-east, Mr. W. L. Willson carried on the work of previous seasons, completing sheets 34, 35, 37, 47 and 48 of the new Topographical survey of Riwah and Bandelkand, including rocks of the Vindhyan, the Bijawar, and the gneissic series.

Mr. Mallet, having had much experience of the crystalline and metamorphic rocks in Bandelkand and the Sóṇ valley, took up an important section of the same rocks in South Behar, with the advantage of the new large-scale maps of Hazáribágh. So far as the comparatively small area of one season's detail-work can be trusted, there seems to be no marked stratigraphical break between the quartzite and slate series of Behar and the gneiss of Bengal. In the middle of the season Mr. Mallet was recalled for some weeks to Calcutta to prepare our mineralogical collections for the Vienna Exhibition.

Far to the south-west of the operations already noticed, Mr. Foote was at work in the South Mahratta country. A section was run across the gneissic area lying between Bellary and the Malparba river, a little to the north of which the south boundary of the Kaladghi series was crossed, and the previous season's work joined on. Various parts of the ground near Kaladghi were gone over again to clear up obscure points. The south-east part of the Kaladghi basin was then surveyed, including the line of outliers extending to Gadjandergarh. From this point the south boundary was carried west to Murgod in Belgaum district. So much of the gneiss area was gone over as was necessary to close in the north-east quarter of sheet 41, and to connect the several quartzite outliers with the general work. After completing the above boundary, work was carried on in the quartzite area around Toragal and Ramdurz, till it became necessary to move into Kaladghi to arrange and despatch the collection of geological specimens for the Vienna Exhibition.

The work remaining to be noticed is external to the rock-area of the Peninsula. In the extreme north-west, Mr. Wynne was engaged in working out the ground to the north of the Salt Range where the tertiary series occupies a large area and forms the outer ridges of the mountain region. The top and bottom horizons are identifiable with the Sivalik and Subathu groups of the sections far to the east, but the same marked divisions of the series are not expressed in the west as in the east. At the base here, although the purely structural features are remarkably like those in the Subathu region, upper secondary formations have been identified in sequence with nummulitic deposits, and of which no trace has as yet been found in the sections described to the east. The presence of such a close sequence of formations would in itself go far to negative here the interpretation that has been given of the features in the Simla region, and thus support Mr. Wynne in rejecting it for the ground he describes. But it is quite possible that both may be right. If widely different modes of action did not occasionally produce similarity of result, the art of observing would be much simpler than it is. These existing discrepancies of fact and of opinion can only be adjusted by the examination of the long stretch of intervening mountains between the Jhilum and the Ravi.

On the south-east side of India, Mr. Theobald completed the survey of Pegu. This work was commenced in the close of 1860 under Mr. Blanford, assisted by Mr. Fedden. In 1862 Mr. Theobald took Mr. Blanford's place; and since 1864 he has been alone at the work, and for eighteen months absent on furlough. On the north the limit of this work is a very broken one; all the formations have a north and south strike, and are thus absolutely cut off along the frontier. On the east the boundary is very regular and natural. At a little to the east of the Salwin in Martaban, along a very steady line, the tertiary formations rest against crystalline matamorphic rocks. The ground to the east of this has not been surveyed topographically. No one who has not made the attempt can form a conception of the difficulty of observing the rocks in a wild tropical region. Rank vegetation produces deep soil; and where the rocks themselves are not very hard, as is the case with much of these tertiary formations, one may march for days through a hill country without getting a fair section of rock in place. There thus remains a great deal to clear up in the geology of Pegu; but the description now published will form an admirable guide to further investigations. Fossils, too, seem to be very scarce. Enough only have been discovered to establish the presence of triassic, cretaceous, and nummulitic strata forming the Arakan Yomah, beneath the general mass of younger tertiary deposits on the east, forming the Pegu Yomah. The south-eastern districts of this province form a totally distinct geological field from that now completed by Mr. Theobald, as marked by the eastern boundary of this area. They are entirely formed of crystalline and sub-metamorphic rocks, in which there is much promise of metalliferous deposits. On this account the mining engineer appointed as mining geologist to the Survey has been deputed to examine those regions. Mr. Fryar reports directly to the Chief Commissioner of British Burmah.

Mr. Ball's work for the season has not yet been noticed: till the middle of February he was engaged in accompanying Mr. Bauerman to some of the coal and iron-fields of Bengal and the Narbada valley. It was quite out of the question that Mr. Ball could then take up his work in the distant wilds of Sirguja; so he occupied the time most usefully in completing the arrangement of our collections for the Vienna Exhibition.

Even if Mr. Bauerman's deputation to India had not so directly touched upon the work of the Geological Survey, it would call for notice here. He is the latest, and no doubt the most competent, of a series of experts sent out from England to report on the practicability of iron manufacture in India on European methods. His preliminary report containing the general result of his observations has been published; but the question seems to stand pretty much as before. Mr. Bauerman has simply restated the case in a more intelligible form than some of his predecessors, but no more so than it has all along been expressed by the Geological Survey—that, under existing circumstances, the Raniganj coal-field is the most promising place for a trial, the principal defect there being the flux; and the Survey has been called upon to furnish further data. The only good to be expected from Mr. Bauerman's visit is, to establish the opinion that actual trial must be the next stage of the enquiry. As an accomplished metallurgist he may also suggest what recent improvements in the art would be most suitable to the circumstances; but, of course, whoever may be entrusted with the conduct of the experiment would form his own opinion upon this point. Meanwhile further search is being diligently made by the Survey for means of surmounting the known material deficiencies.

In the foregoing paragraphs frequent mention has been made of the Vienna Exhibition as having caused interruption to work during the field season, which is already so restricted by the conditions of the Indian climate. This was duly noticed by Dr. Oldham in his last report; and it was shown how largely this circumstance was due to the present crowded and confined condition of our museum and offices, whereby we have been prevented from making even such collections for head-quarters as would sufficiently illustrate our field-work, and much less provide duplicates for distribution or for exhibition elsewhere. It is satisfactory to know that this disability will certainly be shortly removed by our removal during this and the ensuing year into the new Imperial Museum buildings. Once the drawback I have mentioned is removed, the occasional muster of a special collection for foreign exhibition will be altogether a gain—as an incentive to keep up to date, as a means of effecting valuable exchanges of specimens, and, not least, as an opportunity for selected officers to renew their acquaintance with men and things in more civilized regions, and to improve their knowledge in the highly progressive sciences with which we have to deal.

During the present season the distribution of the work is in continuation of that of last year except in the cases of the following officers: Mr. Theobald has been transferred to the North-West Provinces. One of the most interesting problems of Indian Geology awaits solution there—to get materials for unravelling the palæontological sequence in the immense series of deposits based (transitionally) upon the marine nummulitics, and ending above in the deposits containing the great mammalian fauna known as Sivalik. A first step in this enquiry will be to discriminate the proper horizons for the species of the numerous fauna now known as '*Sivalensis*,' derived from strata for which very different stratigraphical positions have been subsequently assigned.

On the urgent requisition of the Government of Bengal to have a mineral survey of British Sikkim and the fringe of the Himalayan range to the east, principally in the hope of discovering some serviceable coal deposit, Mr. Mallet has been detached for that duty. The chief expectation of success rests upon fact that rocks of the Damuda age, containing the well known fossil plants of the Indian coal-measures, are known to occur obscurely along the inner boundary of the tertiary sandstones flanking the mountain range. The occasional carbonaceous deposits in these younger formations themselves have nowhere, as yet seen, offered any encouragement to extended search.

Mr. Hughes has been deputed to carry out some special inquiries regarding the conditions for iron manufacture. He has already reported briefly upon the available deposits of Kumaon, and is now engaged in bringing together additional information to reduce the difficulties of the undertaking in the Raniganj field. It is hoped that there will still be enough of the working season left to admit of his completing the examination of the Wardha coal-field.

Mr. Ball has for the present taken up Mr. Medlicott's work in the Satpura region; and is to afford geological guidance for the boring operations. Mr. Hacket has resumed his work in Rajputana, which had to be suspended some years ago on account of the famine in that region. Mr. Medlicott is to devote what time he can spare for field-work to an examination of the coal recently discovered in the Garo hills. This coal can be certainly identified with the cretaceous coal of Sijn and Maobilurkar in the same region. It appears to lie in an interior basin, the existence of which was not suspected. Until within the last five years these hills were as completely, on a small scale, a *terra incognita* as Central Asia, all approach being forbidden on account of the savage propensities of the inhabitants.

It remains to notice a new feature in the constitution of the Survey. It was said above that the last vacancy that occurred in the staff, by the transfer of Mr. J. Willson to the Educational Department, has not been filled up, the Government having decided to devote the pay of that appointment to the attempt to train native geologists. The scheme has in a way grown out of, though it can scarcely be said to be a development of, endeavours made by Dr. Oldham from time to time to establish teaching in certain branches of science in connection with the Geological Survey, that some general knowledge of these subjects might be diffused, and no doubt with the ulterior view that if this teaching bore fruit, the Survey might benefit by obtaining competent workers. Dr. Oldham's proposal would have involved some expense, in the shape of remuneration to the teachers. The present scheme avoids this objection, but is not free from others. It begins by curtailing the effective staff of the Survey; for years to come, moreover, these attached students must be a direct incumbrance; and there is small guarantee that they can ever be otherwise—that they will ever be fit for independent work. The superficial discrimination of stones that used to pass muster as geology, and does so still with the majority, is really of no kind of value in the present state of knowledge. Geological observations to be of any use or interest must include much that is not obvious to the naked eye. And in any country like India, where the means of locomotion are so cumbrous, a surveyor who cannot describe and discuss his observations, or who cannot be trusted to observe correctly, is comparatively useless, as it takes nearly the whole time of a competent man to check and direct his work. It is not here assumed either that natives cannot be taught geology, or that it requires a high order of intelligence to attain moderate proficiency as a geologist. It does, however, essentially require a modernized intelligence; the work being even in its lowest steps the rational interpretation of nature—the most elementary positions of the science being not statements of obvious fact, but inductive conclusions through a postulated causation. It is this that makes geology so singularly inappropriate for the initiation of the primitive cast of mind. Geology is pre-eminently a science having no corresponding art or practice in the proper meaning of the words, in which work can be done according to prescribable rules. Every geological act involves a deliberate judgment. The industrial undertakings occasionally based upon such judgments, involve only mechanical skill of a rough order, requiring no recognition of geological principles. These remarks may seem somewhat fine-drawn; but I think it right to represent this experiment for once under its essential conditions. The natives of India having as yet shown such little aptitude for acquiring physical knowledge in any of its branches, there seems small encouragement to force them directly into the application of one of the most complex developments of that knowledge. There are to be four native apprentices; one joined in March last, and three are about to join. They are all students of the Lahore College, no applicants having come forward from the North-Western Provinces. Their qualifications consist of a moderate knowledge of English and of elementary mathematics. It was at first prescribed that they should be immediately put into geological harness. But sanction has now been given to their attending one or more courses of physical science lectures at the Presidency College. The fact of their being already appointed to the Survey, though only as probationers, is not perhaps the most likely way to stimulate their studies. At the worst we may look forward to utilizing them as fossil-collectors.

PUBLICATIONS.—The quarterly RECORDS OF THE GEOLOGICAL SURVEY OF INDIA have been published regularly, containing numerous papers, both of general interest and of practical bearing. The first number, besides the annual report, contains a sketch of the geology of the North-West Provinces. This is the only province in India of which every part has been, more or less, cursorily visited. In the second number there is a map and description of the Bisrampur coal-field, which is about the centre of the extensive spread of these formations nearly continuous in the region of the upper Són and the northern tributaries of the Mahanadi. The coal-basins of this latter area will become of great importance when the direct route is established between Calcutta and Bombay. Mr. Mallet contributes additional mineralogical notes on the crystalline rocks of south Mirzapur. In the August number there is a brief discussion of the question of the geological age of our old river valley deposits, in which during the season's work in the Narbada valley Mr. Hacket had found a most symmetrically formed stone implement. The object of the paper is, by an examination of the stratigraphical features, and the comparison of them with those of established formations in Europe, to give a purely geological statement a most interesting question that had hitherto rested upon somewhat vaguely expressed palæontological surmises. A preliminary notice is given by Mr. King of the Beddadanole coal-field, about thirty-five miles north-west of Rajamundri, and by far the nearest known deposit to the sea-board of the Godavari delta. As yet nothing can be said of the prospects of the field. The trial borings are only commencing. Mr. Wynne contributes a sketch of the geology of the Rawal Pindi region, showing the enormous continuous development of the tertiary series. A comparative statement of the coal-measure areas of different countries, as compared with India, is drawn up by Mr. Hughes; and Mr. Theobald gives a description and list of the brine-springs of Pegu, the exploitation of which is now almost entirely superseded by the importation of salt and the manufacture of sea-salt. The fourth number contains a note by Mr. Hughes on some iron deposits of Chanda, Mr. Ball's description of Barren Island, and some memoranda by Mr. Theobald upon the metalliferous localities of British Burmah.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA, the first part of volume X was issued early in the year. It contains a carefully written description by Mr. R. Bruce Foote of a large tract of country close to Madras, comprised in the eastern half of sheet 78 of the Indian Atlas. This is separately issued in two quarter sheets, geologically coloured. Besides the gneiss, the oldest formation occurring here is that well known in Indian geology as the Rajmahal group, the Oomia zone in Dr. Stoliczka's classification of the Kach rocks, and considered by this most competent authority to be of uppermost jurassic age. There are also several distinguishable deposits of tertiary and post-tertiary age, in some of which are found the rude stone implements described by Mr. Foote some years ago. This part also contains a tentative sketch with skeleton map of the Satpura basin of the coal-measure series by Mr. Medlicott. This ground seems to offer a fuller development of this great rock-series than any other area in India—from the zamia-bearing Jabalpur group, probably the same as the Rajmahal, through the Mahadeva strata and underlying beds presumably of Panchet and Damuda (Kamthi) affinities, to the typical Barakar and Talchir rocks at the base. Parts of the northern side of the basin were carefully examined, the lie of the coal-measures discovered, and indications given for trial borings. Part 2 of this volume, containing Mr. Theobald's description of the geology of Pegu, is also virtually published, the whole impression having been struck off in October, the delay being in the lithographing and colour-printing of the map.

The issue of the PALÆONTOLOGIA INDICA for the whole year was made in April and May. With a view to the Vienna Exhibition, and to admit of his going there himself, Dr. Stoliczka made great efforts to get in advance of his work. The parts then issued contain the Echinodermata, Anthozoa, Sponges, Foraminifera, Arthrozoa, and Spondylozoa, forming the fourth and last large volume of the Cretaceous Fauna of Southern India. The fullest testimony has been offered by the most competent authorities to the excellence and value of this work. For the same object an effort was made to prepare and issue the first fasciculus of the series describing the jurassic fauna of Kach by Dr. Waagen. It contains the Belemnitidæ and Nautilidæ, and was issued in June, being the number in advance for the first quarter of 1874. There is a quantity of manuscript and of drawings in an advanced state of preparation, and if either Dr. Waagen or Dr. Stoliczka is able to return, even late in the year, the publication can be readily brought up to date.

MAPS.—The first of the systematic publication of our maps on the scale of one inch to the mile, as recently sanctioned, was made this year by the issue of the twelve sheets of the district Dumoh; several sheets of the adjoining region are ready to send to press. I cannot but express my decided opinion that the publication of the greater part of our work on this scale is premature and wasteful, neither the maps nor the geology being worth it. I say this advisedly, and because I am quite prepared to defend the excellence of the maps to the degree of accuracy that can be expected in them. We have for the most part to deal with rocky and hilly ground, and tracts of this description generally come under the Topographical system of survey. It would altogether defeat the objects of this mode of survey, which are expedition and moderate cost, if it were to attempt the same accuracy of detail that is expected from the method of the Revenue Survey. For all ordinary purposes of geography, and for all rough practical purposes, as well as general geological structure, these maps are all that need be required. But close geological work is as severe a test as a map can be put to; and I have often had to give up the attempt to make the geological features agree accurately with the lines of these maps. I can speak even more positively of the geological objection Take these very maps of Dumoh; they only represent the boundaries of the overlying trap, the divisions of the Vindhyan series (generally several hundred feet in thickness), and the outcrops of the inter and infra-trappeans, all in the simplest relation of horizontal superposition. There is no single feature of scientific interest or of practical utility calling for any minuteness of delineation, and that cannot be adequately indicated on the quarter-inch scale. It is certainly necessary that the field work should be executed on the one-inch scale if only to ensure all possible accuracy on the smaller map; but once this reduction has been carefully made, and with an explanatory text, it would be of small consequence if the field-maps were destroyed. The most complete geological map possible would be of no use in the hands of one who scarcely knows one rock from another; and for one who does, the quarter-inch maps will be sufficient guide over nine-tenths of the geological work likely to be done in India for many a year to come.

While on the subject of large scale maps, I would urge the importance of having really adequate working maps of certain tracts where the utmost amount of accuracy and of geological detail is called for. Such a map is now greatly needed on the scale of four or six inches to the mile for the Raniganj coal-field, where mining enterprise is so active.

Of the Atlas of India maps, quarter sheet 77 S. W. was published during the year; and several of the adjoining sheets are ready for the engravers. The printing of these has not been pressed on account of some uncertainty as to corrections, which could not be settled in the absence of Mr. King. This is of less consequence, as a skeleton map of most of the area was issued with the descriptive memoir published last year. As these Atlas sheets are to be our final and general form of publication, it is of great importance to decide upon a permanent scale of colours, so as to have the series uniform; and it is very difficult to do this safely while the scale of formations itself is under discussion. Once this difficulty is surmounted, we shall be in a position to publish a good number of these quarter sheets.

LIBRARY.—The library has received the addition of 614 volumes or parts of volumes during the year, of which number 477 were presented, and 137 purchased. This number would have been much larger, save for the unfortunate miscarriage of a large consignment of books from Berlin. It is hoped that the case has only gone astray and will be recovered.

It has now been several months missing. The detailed list of these additions has been regularly published in the RECORDS; and a list of the institutions from which presentations or exchanges have been received is annexed.

MUSEUM.—Occasional donations to the museum have been duly acknowledged in the RECORDS. Mr. Mallet was able, during the recess, to get through a considerable section of his descriptive catalogue of mineral collection. The preparation for the Vienna Exhibition entailed no small additional labour upon all hands; but the success achieved has been most gratifying to all. The parts of those collections to be received back have not yet arrived. The series of specimens in the museum are in good order.

H. B. MEDLICOTT,
Offg. Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
January 1874.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1873.

BATAVIA.—Royal Society of Batavia.
BELFAST.—Natural History and Philosophical Society of Belfast.
BERLIN.—German Geological Society.
„ —Royal Academy of Science.
BOSTON.—Boston Society of Natural History.
BRUXELLES.—Royal Academy of Science.
CALCUTTA.—Asiatic Society of Bengal.
CAMBRIDGE-MASS.—American Academy of Arts and Sciences.
„ —Museum of Comparative Zoology.
CHRISTIANIA.—Royal University.
COPENHAGEN.—Danish Academy.
DRESDEN.—The Isis Society.
DUBLIN.—Royal Dublin Society.
„ —Royal Geological Society of Ireland
EDINBURGH.—Royal Society of Edinburgh.
FLORENCE.—Geological Commission of Italy.
GLASGOW.—Philosophical Society of Glasgow.
GÖTTINGEN.—The Society.
INDIANAPOLIS.—Geological Survey of Indiana.
LAUSANNE.—Society of Natural Sciences.
LIVERPOOL.—British Association for the advancement of Science.
LONDON.—British Museum.
„ —East India Association.
„ —Geological Society of London.
„ —Royal Asiatic Society.
„ —Royal Institute of Great Britain.
„ —Royal Geographical Society.
„ —Royal Society.
„ —India Office.
MELBOURNE.—Royal Society of Victoria.

MINNEAPOLIS.—Academy of Natural Sciences, Minnesota.
MONTREAL.—Geological Survey of Canada.
MOSCOU.—Imperial Society of Naturalists.
MÜNICH.—Royal Bavarian Academy of Science.
NEUCHATEL.—Society of Natural Sciences.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—Geological Survey of France.
" —L'Administration des Mines.
PHILADELPHIA.—Academy of Natural Sciences.
" —American Philosophical Society.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Peabody Academy of Science.
" —Essex Institute.
STOCKHOLM.—Bureau Recher. Geol. Suede.
" —Royal Academy of Science.
ST. PETERSBURG.—Imperial Academy of Sciences.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Science.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—K. K. Geologische Reichsanstalt.
" —Vienna Academy.
WASHINGTON.—Smithsonian Institute.
" —Department of Agriculture of the United States of America
" —Department of State, Washington, D. C.
" —United States Geological Survey.
WELLINGTON.—New Zealand Institute.
YOKOHAMA.—German Natural History Society.
ZÜRICH.—Natural History Society.

Governments of Bengal, Bombay, India, Madras, [redacted], and North-Western Provinces; Chief Commissioners of British Burma, Central Provinces, and Mysore; the Surveyor General of India, the Resident, Hydrabad, and the Superintendent of the Great Trigonometrical Survey of India.

A BRIEF ACCOUNT OF THE GEOLOGICAL STRUCTURE OF THE HILL-RANGES BETWEEN THE INDUS VALLEY IN LADAK AND SHAH-I-DULA ON THE FRONTIER OF YARKAND TERRITORY, *by* DR. F. STOLICZKA, *Geological Survey of India, Naturalist attached to the Yarkand Embassy.*

The following brief notes on the general geological structure of the hill-ranges alluded to, are based upon observations made by myself* on a tour from Leh, *viâ* Changchenmo, the high plains of Lingzi-thang, Karatagh, Aktagh to Shah-i-dula, and upon corresponding observations made by Dr. H. W. Bellew, accompanying His Excellency Mr. Forsyth's camp along the Korakorum route to this place.

Before proceeding with my account, I will only notice that our journey from Leh (or Ladak) was undertaken during the second half of September and in October, and that we found the greater portion of the country north of the Changchenmo valley covered with

* As a member of a detached party, specially deputed by His Excellency the Envoy, Mr. T. D Forsyth, C. B., to explore the Changchenmo and Lingzi-thang routes.

snow, the greatest obstacle a geologist can meet on his survey. While on our journey the thermometer very rarely rose during the day above the freezing point, and hammer operations were *not easily* carried out. At night the thermometer sank as a rule to zero, or even to 8° below zero in our tents, and to 26° below zero in the open air. Adding to this the natural difficulties of the ground we had to pass through, it was occasionally not an easy matter to keep the health up to the required standard of working power.

Near Leh, and for a few miles east and west of it, the Indus flows on the boundary between crystalline rocks on the north and eocene rocks on the south. The latter consist chiefly of grey and reddish sandstones and shales, and more or less coarse conglomerates, containing an occasional *nummulite* and casts of *pelecypods*. These tertiary rocks extend from eastward south of the Pangkong lake, following the Indus either along one or both banks of the river, as far west as Kargil, where they terminate with a kind of brackish and fresh-water deposit, containing *melaniæ*.

Nearly the entire ridge north of the Indus, separating this river from the Shayok, and continuing in a south-easterly direction to the mouth of the Hanle river (and crossing here the Indus, extending to my knowledge as far as Demchock), consists of syenitic gneiss, an extremely variable rock as regards its mineralogical composition. The typical rock is a moderately fine-grained syenite, crossed by veins which are somewhat richer in hornblende, while other portions contain a large quantity of schorl. Both about Leh and further eastward, extensive beds of dark, almost black, fine-grained syenite occur in the other rock. The felspar often almost entirely disappears from this fine-grained variety, and quartz remains very sparingly disseminated, so that gradually the rock passes into a hornblendic schist; and when schorl replaces hornblende, the same rock changes into layers which are almost entirely composed of needles of schorl. Again, the syenite loses in places all its hornblende, the crystals of felspar increase in size, biotite (or sometimes chlorite) becomes more or less abundant, and with the addition of quartz we have before us a typical gneiss (or protogine gneiss) without being able to draw a boundary between it and typical syenite. However, the gneissic portions, many of which appear to be regularly bedded, are decidedly subordinate to the syenitic ones. As already mentioned, the rock often has a porphyritic structure, and the felspar becomes pink instead of white, as, for instance, on the top of the Kardung pass and on the southern slope of the Chang-la, where large fragments are often met without the slightest trace of hornblende. To the north of the last mentioned pass the syenitic gneiss gradually passes into thick beds of syenite-schist, and this again into chloritic schist, by the hornblende becoming replaced by chlorite, while the other mineral constituents are gradually almost entirely suppressed. The syenitic and chloritic beds alternate with quartzose schists of great thickness. This schistose series of rocks continues from north of the Chang-la to the western end of the Pangkong lake, and northwards to the Lunker-la, generally called the Marsemik pass. On the western route Dr. Bellew met similar rocks north of the Kardung pass at the village Kardung, and traced them northwards across the Shayok, up the Nubra valley to near the foot of the Sussir pass.

Intimately connected with the metamorphic schistose series just noticed, is a greenish chloritic, partly thin-bedded, partly more massive rock, which very closely resembles a similar rock found about Srinaggar. Only in this case certain layers, or portions of it, become often distinctly or even coarsely crystalline, sometimes containing bronzite sparingly disseminated, and thus passing into diallage. This chloritic rock forms the greater part of the left side of the Changchenmo valley, and also occurs south of the Sussir pass. I think we have to look upon this whole series of schistose and chloritic rocks as the representatives of the *silurian formation.*

After crossing the Changchenmo valley to Gogra, we met with a different set of rocks. They are dark, often quite black, shales alternating with sandstones. Many beds of the latter have a comparatively recent aspect, and are rather micaceous, without the least metamorphic structure, while the shales accompanying them very often exhibit a silky, sub-metamorphic appearance on the plains of fracture. I observed occasionally traces of *fucoids* and other plants in these shales, but no animal fossils. On the Changchenmo route these shaly rocks forms the ridge of the Chang-lang pass, as well as the whole of the western portion of the Lingzi-thang; and they are met again after crossing these high plains and entering the Karakash valley, as far as Shinglung (or Dunglung). On the Korakorum route Dr. Bellew brought specimens of similar rocks from the Korakorum range itself. There can be but little doubt,—judging from similar rocks which I saw in Spiti, and from their geological relation to certain limestones, of which I shall presently speak—that we have in the shaly series the *carboniferous formation* represented.

In many localities along the right bank of the Changchenmo river, then at the hot springs north of Gogra, and on the southern side of the Chang-lang pass, we find the carboniferous beds overlain by *triassic limestone* which often has the characteristic semi-oolitic structure of the Krol-limestone south of Simla. At Gogra and several other places dolomitic beds occur; and in these, sections of *Dicerocardium Himalayaense* are not uncommon. In other places beds are met with full of *crinoid* stems. North of the Lingzi-thang plain—to the west of which the hills are mostly composed of the same triassic limestone—a red brecciated, calcareous conglomerate is seen at the foot of the Compass-lá, but this conglomerate gradually passes into the ordinary grey limestone, which forms the ridge, and undoubtedly belongs to the same group of triassic rocks. The last place where I saw the triassic limestone was just before reaching the camping ground Shinglung; here it is an almost white or light grey compact rock, containing very perfect sections of *Megalodon triqueter*, the most characteristic triassic fossil. On Mr. Forsyth's route Dr. Bellew met with similar triassic limestones on the northern declivities of the Sussir pass, and also on the Korakorum pass overlying the carboniferous shales and sandstones previously noticed. On the Korakorum the triassic limestone contains spherical corals very similar to those which had been a few years ago described by Professor Ritter von Reuss from the Hallstadt beds in the Alps, and which are here known to travellers as Korakorum stones. A description of these very remarkable corals will be given subsequently.

Returning to our Lingzi-thang route, we leave, as already mentioned, the last traces of triassic limestone at Shinglung, in the upper Karakash valley. Here the limestone rests upon some shales, and then follow immediately the same chloritic rock which we noticed on the Lunker-la, alternating with quartzose schists, both of which must be regarded as of upper palæozoic age.

At Kizil-jilga regular sub-metamorphic slates appear, alternating with a red conglomerate and red sandstones, and further on dark slate is the only rock to be seen the whole way down the Karakash, until the river assumes a north-easterly course, some fourteen miles west of the Karatagh pass. From here my route lay in a north-westerly direction towards Aktagh, and the same slaty rock was met with along the whole of this route up to the last mentioned place. Dr. Bellew also traced these slates from the northern side of the Korakorum to Aktagh. They further continue northwards across the Suget-lá, a few miles north of the pass, as well as in single patches down the Suget river to its junction with the Karakash. The irregular range of hills to the south of the portion of the Karakash river, which flows almost east-west from Shah-i-dula, on its southern side entirely consists of these slates, while on the northern side it is composed of a fine-grained syenite, which also forms the whole of the Kuenlún range along the right bank of the Karakash river, and also is the sole rock composing the hills about the camping ground Shah-i-dula. The slates of which I spoke are, on account of the close cleavage, mostly fine, crumbling, not metamorphic, and must, I think, be referred to the silurian group. They correspond to the metamorphic schists on the southern side of the Korakorum ranges.

Thus we have the whole system of mountain ranges between the Indus and the borders of Turkistan bounded on the north and south by syenitic rocks, including between them the silurian, carboniferous, and triassic formations. This fact is rather remarkable, for, south of the Indus, we have nearly all the principal sedimentary formations represented from the silurian up to the eocene, and most of the beds abound in fossils.

The only exception to which I can allude on the Changchenmo route is near Kium, in the Changchenmo valley. Here there are on the left bank of the river some remarkably recent looking sandstones and conglomerates, dipping at an angle of about 45° to north-by east, and at the foot of these beds rise the hot springs* of Kium. I think it probable that this conglomerate has eastward a connection with the eocene deposits, which occur at the western end of the Pangkong lake, and in the Indus valley south of it.

In the previous notes I have scarcely alluded to the dip of the rocks at the different localities. The reason is that there is indeed very great difficulty in directly observing both the dip and the strike. At the western end of the Pangkong lake the dip of the metamorphic schists is mostly a south-westerly one, but further on nearly all the rocks dip at a moderate angle to north-east, north-by-east, or to north. On the Lingzi-thang, just after crossing the Changlang, the shales are mostly highly inclined, but further on the limestones lie unconformably on them and dip to north-east. Wherever the hills consist merely of shales and slates, their sides are generally so thickly covered with débris and detritus that it becomes almost an exception to observe a rock *in situ*.

The débris is brought down in large quantities by the melting snow into the valleys, and high banks of it are everywhere observable along the water-courses. At a somewhat remote—say diluvial—period this state of things has operated on a far greater scale. Not only were the lakes, like the Pangkong, much more extensive, but valleys like the Changchenmo, or the Tanktze valley, sometimes became temporarily blocked up by glaciers, or great landslips, and the shingle and clay deposits were often accumulated in them to a thickness of two or more hundred feet. Near Aktagh similar deposits of stratified clay exist of about 160 feet thickness, and extend over an area of more than one hundred square miles. There can be but little doubt that when these large sheets of water were in existence, the climate of these now cold and arid regions was both milder and moister, and naturally more favorable to animal and vegetable life than it is now. A proof of this is given, for instance, by the occurrence of subfossil *Succineæ*, *Helices*, and *Pupæ* in the clay deposits of the Pangkong lake, while scarcely any land mollusk could exist at the present time in the same place.

NOTES ON SOME OF THE IRON-ORES OF KÚMAON, BY THEODORE W. H. HUGHES, A. R. S. M., F. G. S., GEOLOGICAL SURVEY OF INDIA.

In connection with the highly important subject of the establishment of iron works in this country on the large scale, I was called upon in October last by Government to investigate the mode of occurrence and to determine the quality of some iron-ores in the province of Kúmaon.

My attention was directed to no new localities; I was instructed to visit ground that had already been so reported upon, written about and discussed, that it possessed a literature of its own on the special subject of iron, of more than five hundred octavo pages.†

* The temperature of these hot springs varies from 60° to 125°. They form no deposit of gypsum, like the springs north of Gogra, but there is a good deal of soda deposit round them.

† Selections from the Records of the Government of India, No. VIII, 1855.
" " " " " " " Supplement to No. VIII, 1855.
" " " " " " " " " XVII, 1856.
" " " " " " " " " XXVI, 1859.
Report on the Government iron works at Deechouree in Kúmaon, by Thomas Oldham, Esq., 1860.

There was no time, and perhaps no necessity, for me to make an exhaustive examination of the capabilities of the entire province; but my work would have been personally more satisfactory if, by more extended research, I had been able to assure myself that no essential points had escaped the observation of my predecessors.

Acting upon the orders conveyed by letter through Colonel Ramsay, C. B., Commissioner of Kúmaon—"to report generally upon the quantity and quality of the ores and fluxes in the neighbourhood of Rámgarh, Khairná, Káládhúngí, and Déh-chaurí"—I proceeded as soon after the cessation of the rains as possible to examine each locality indicated.

Colonel Drummond, Dr. Oldham, and Messrs. Henwood, Sowerby, Barret, Davies, Watson, and Bauerman have expressed views as to the prospect of Káládhúngí and Déh-chaurí furnishing ore and flux, and I find on comparing their opinions that with the exception of Mr. Henwood in 1855, and Mr. Bauerman in 1873, they entertain the belief that ore is very plentiful. In this belief I coincide. I have only to temper the too high estimate formed of the quality of the ore.

RÁMGARH.

Under this heading it will be convenient to refer to several places in the same geological region, but at some distance apart—namely, Páhlí, Loshgiání, Natúá Khan and Parwárá.

Pahlí.—This locality is near the Rámgarh suspension bridge and on the right bank of the Kálápání river. I am sorry to say there was no means of gaining any knowledge as to the existence or quality of ore other than by the examination of some waste heaps near the mouths of two deserted galleries. A sample of ore was brought in and analyzed. It yielded 42·93 per cent. of iron. This is but a low percentage, and may be accounted for by supposing that the waste mass from which the ore was picked out contained only poor specimens. At Natúá Khan and other localities where the same variety of ore (micaceous hæmatite) occurs the average percentage of iron is much greater.

Loshgiání.—Iron-ore has been extensively wrought near Loshgiání. There are two distinct beds, the Gwálákúrí and the Khánípáká. The ore, which is least rich in iron, is that of the Gwálákúrí bed.

Its outcrop is well defined, and by clearing away a little earth, I was enabled to obtain what I consider a fair sample of the ore, which is a rather dense brown hæmatite, yielding 52·4 per cent. of iron. The minimum thickness of the bed is 8 feet. I have not been able to find any reference to the quality of this iron in any of the books which I have consulted. I suspect that its external appearance, which is certainly not indicative of such a high percentage, as analysis shows it to contain, condemned it in the eyes of those to whom the soft, bright, micaceous hæmatites of the neighbourhood had recommended themselves.

The Khánípáká bed is distinct from that of Gwálákúrí, although on almost the same horizon. It has been largely mined by the natives, and the number of shafts that have been sunk to reach the ore is something extraordinary.

I was anxious to obtain access to some underground workings, in order to estimate the thickness of the bed; but when I saw that the only means of descent was by a rope down which one had to slide to a depth of 80 to a 100 feet, and then come up again hand over hand, and that the shaft was neither straight nor dressed, I was obliged to acknowledge that to gain my end would necessitate the performance of a feat somewhat beyond my powers. In consequence, I can merely repeat what the natives told me, that the bed varied from 6 to 8 feet in thickness. A large amount of the ore is stacked in the yard adjoining the partly erected furnace near the village of Rámgarh. It seemed unnecessary to have the percentage of iron determined, as it appears to be of quite as high a value as the Natúá Khan ore, the analysis of which will be found further on.

Natúá Khan.—This is one of the most celebrated localities for the ores, coming under the general heading of Rámgarh. It possesses, however, no claim to superiority over Loshgiání, either on the score of better quality of ore or greater thickness of bed. The accident of its propinquity to the main road between Naíni Tál and Almora renders it easy of access, and therefore brings it more into notice.

There is no outcrop of the bed visible; and, as in the case of Loshgiání, I have to rely on the statement of the natives who worked it underground, that its total thickness is 9 feet, including a parting that varies from 1 to 2 feet. A specimen of the ore, which I obtained near the old workings, yielded 61·33 per cent. of iron. Dr. Macnamara,* who analysed a sample forwarded by Colonel Drummond in 1855, gives the result of his examination as 70·72 of iron. This is, of course, a very high percentage, and the average is probably nearer the result obtained in our office.

Parwárá.—This locality is several miles from Rámgarh, but as I had heard of it spoken of as possessing a bed of good ore, I went there. I found on my arrival that there was no opportunity of inspecting the ironstone *in situ*, every pit that had been sunk having filled in. I tried to open out one of them, but two days' working convinced me that a month would be required to get down and expose the bed, and I contented myself by taking away a specimen of the ore from amongst a few pieces that the headman of the village had in his house. It was brown hæmatite, mixed with a great deal of calcareous matter. The result of analysis was 29·61 per cent. of iron and 43 per cent. of carbonate of lime. Although the quantity of iron is small, this ore would be valuable to mix with others, on account of the carbonate of lime with which it is associated.

There were several mines in the neighbourhood which I might have looked at, but as they were all abandoned, and there was nothing to see at the surface beyond the rocks in which the ironstone occurred, I wasted no time over them.

SUMMARY.—The examination of the few localities I have visited convinces me that in the Rámgarh area the *ores are rich, abundant*, and may be easily worked.

The Loshgiání and Natúá Khan beds have only to be mined upon some rational system to yield an enormous amount of ore. Dr. Oldham, in his report of 1860,† when referring to Rámgarh, says, "there is not the slightest possibility of the want of ore being felt; there is the greatest abundance."

Flux.—Lime-stone occurs in the immediate vicinity of the ironstone at Natúá Khan. It yields by analysis 67·6 per cent. of carbonate of lime, and the rest is chiefly clay. This is not equal to the purity of limestones generally in use in England, which contain 93 to 97 per cent. of carbonate of lime; but an impure limestone can be employed advantageously at times, when the ore of iron is of such a composition that it requires some foreign earths to be added. I am not aware of any purer limestone occurring near Natúá Khan or Loshgiání.

KHAIRNÁ.

From Rámgarh I proceeded to Khairná, and after examining the iron-ore there went to Tatail and Kalúágarh, which are villages in the valley of the Kosí, distant about three and seven miles respectively from Khairná.

Khairná.—A bed of quartzite, in which small veins of red hæmatite are found, occurs near to the old suspension bridge at the confluence of the Kosí and Khairná rivers. I cannot report favorably of this locality as a source of supply; for, though the ore considered

* Selections from the Records of the Government of India, Supplement to No. VIII, 1865, page 87.

† Report on the Government iron-works at Deohouree, in Kúmaon, by Thomas Oldham, Esq., 1860, p. 24.

merely as an ore is good, it is too much scattered through the matrix for profitable working. Mr. Sowerby speaks highly of Khairná, and says—"I have no doubt whatever but that the deposit is very considerable, and there is a good back (hill) to work upon." Our opinions differ.

Tatail.—Two veins of ironstone were pointed out to me near Tatail. One measuring eight to twelve inches in thickness, and dipping to the west at an angle of 30°, occurs in a hill to the south of the village, and is associated with Tálcose shale and dolomite. The amount of carbonate of lime in the dolomite is 65·1, and the remainder is carbonate of magnesia and clay.

I could not obtain a large sample of the ore, which is micaceous iron, as there are no longer any surface workings, but I was able to pick off a small piece from the side of the vein, and it yielded by analysis 48·77 per cent. of iron.

The other vein, containing magnetite, occurs west of the village and on the left bank of the Simrárá Gadhérá. It is of small size, and it has never been holed for the sake of the ore. The native agars merely collect the fragments that may be occasionally brought into the bed of the stream by slips of the bank. The assay of the ore gave 50·11 per cent. of iron.

Kalúágarh.—My visit to this place was labour entirely thrown away, as I could see nothing more than a small hollow in clay where iron-ore was once obtained.

SUMMARY.—Of the different localities which I have alluded to in the Khairná area, there is not one which gives promise of much ore. I cannot say what the valley of the Kosí might yield between Kalúágarh and the Bhábar; but in the section of it which I examined, there was nothing to justify the hope that Khairná was a valuable district for ironstone. It would be well if we knew what the capabilities of the Kosí valley were lower down, where the accessibility from the plains might render deposits of rich and abundant ore more than usually valuable, in order to mix them with the poorer varieties of the Bhábar.

Flux.—As there is no probability that any demand for limestone to be used in iron furnaces will arise near Khairná, the question as to its occurrence or not is not of much importance.

KÁLÁDHÚNGÍ.

Owing to the interest attaching to this well known resting place for people either going to or coming from Naíni Tál, as having once been the scene of actual smelting operations on the large scale, I went carefully over the ground with Mr. Matthews, the Secretary to the Kúmaon Iron Company, and examined the deposit of iron-ore which occurs between the two extreme points known as Loha Bhar Bhar and Dhariá Khérá. It is a much more recent formation than the iron-ores of Rámgarh and Khairná, being possibly of tertiary age. It occurs with the clays and sandstones of the Nahun group, which form the low fringing hills to the north of Káládhúngí, but whether interstratified with them or unconformable to them it is difficult to say. There is one section in the main road to Naíni Tál, about a mile from the dâk bungalow at Káládhúngí, where the ironstone has been cut through, and it appears to be conformable to the beds below it. This may, however, be quite accidental.

Mr. Medlicott informs me that further west, to as far as Nahun, similar beds of ferriferous clay occur, though not so rich as at Déh-chaurí, and undoubtedly forming an integral portion of the Nahun group, (tertiary). This is a point of considerable practical importance, for if the deposit be unconformable to, instead of being interstratified with, the clays and sandstones, the ironstone at the surface is to a considerable extent the measure of its quantity, whereas if it be a bed in the series, it will yield a much greater body of ironstone than is now exposed to view.

Even taking the most unfavorable view of the case, however, there is an immense mass of ore. I was somewhat sceptical at first as to the quantity being large, but half an hour's steady walking over a more or less continuous band of it, removed any doubts that I had entertained.

I cannot, however, speak very enthusiastically about the general quality of the ore. A sample, which I consider contains more than the average quantity of iron, yielded 49·91 per cent. of protoxide, or 38·82 per cent. of metallic iron.

On referring to the printed records on the subject, I find that in trial-assays made by Mr. Davies* the percentages of iron were 48, 47, 40, and 28; Piddington gives the maximum as 52 and 29. And Dr. Macnamara from best quality samples obtained 48·53 per cent.

SUMMARY.—No appreciation of the value of the Káládhúngí deposit can be made by merely reading a series of maximum and minimum percentages of samples sent in to an analyst. One must go over the ground as I did to see what the general proportion of rich to poor ore is—and I am of opinion that the poor ore predominates. At first sight this statement might appear to condemn the Káládhúngí ironstone, but this is not the case, for if the "getting" of it were properly supervised by some person who could distinguish the good from the bad portions, the deposit is so large that an immense amount of superior ore might be made available for smelting. Unless some plan of discrimination, however, is adopted, a mixture of high and low class ores will take place, and as the better class of ore is not extravagantly rich, it will do no more than just raise the entire mass above the standard of condemnation.

Flux.—Limestone blocks occur in several of the small streams near Káládhúngí, and notably in the Baur river. An estimate of quantity is scarcely called for, as the supply is more than ample for the wants of half a dozen furnaces.

DÉH-CHAURÍ.

The ironstone which occurs at Káládhúngí extends westward to Déh-chaurí. Mr. Sowerby spoke highly of the Déh-chaurí ore, and asserted that it was more abundant than the deposit at Káládhúngí. This latter statement was a point which Mr. Matthews, equally with myself, wished to investigate, and we spent three days in looking up every section that was to be seen, and we came to the conclusion that the deposit of ore was less extensive than that at Káládhúngí, but the quality was generally much better. Several different *beds* are spoken of by Mr. Sowerby as being *in situ*, but I can neither confirm nor disprove this assertion. None of the natural sections furnished me any satisfactory evidence, and to have opened out a shaft, or driven an adit, would have occupied two or three months. With only the quantity of ore, however, to operate with that I saw on the surface, there is enough to supply all the requirements of the number of furnaces that are ever likely to be kept in blast at Déh-chaurí, so that whether three beds or four beds exist is really not of much consequence.

The following analyses of Déh-chaurí and Káládhúngí ores exhibit side by side the composition of samples which are somewhat above the average quality :—

	Déh-chaurí.	Káládhúngí.
Loss in heating ...	4·58	7·67
Oxide of iron ...	70·88	49 91
Alumina ...	4·79	5·27
Lime ...	3·11	1·1
Phosphoric acid ...	1·67	·66
Silica and insoluble ...	15·81	36·62
	100·84	100·23
Metallic iron ...	55·13	38·82

There was no sulphur, and the amount of phosphorus is not excessive.

* Selections from the Records of the Government of India, Supplement to No. VIII, 1865, page 41.

Flux.—Limestone may be picked out of the channel of the river Baur, and in several of its minor tributaries. Enormous blocks are strewn on the same hill side in which the iron-ore exists; and I am informed that a tufa deposit occurs within a reasonable distance of Déh-chaurí.

GENERAL SUMMARY.—Summarising in a few words the result of my investigation regarding the iron-ores, I have to state—

Ores.—That in the Rámgarh circle, the ore is good and plentiful.

That in the Khairná circle, the iron-ores are not of much value.

That in the Káládhúngí circle, the ore is not as good as those occurring in the Rámgarh circle, but the supply is very great.

That in the Déh-chaurí circle, the average quality of the ore is superior to that at Káládhúngí, and the quantity is large.

Limestone.—No fear need be entertained about the supply of limestone for fluxing. Every authority agrees in testifying to its abundance.

Although my duty was only to report upon the quantity and quality of the iron-ores at the places indicated in my instructions, I would beg to make a few remarks in view of the possible resuscitation of the manufacture of pig-iron in the Bhábar, at Káládhúngí, and Déh-chaurí.

Such an attempt *cannot* fail through paucity of ore or flux. Water-supply is available throughout the driest season of the year, as is proved by the fact that the furnaces of the Kúmaon Iron Company were in blast until the 5th of June. The reproductive power of the forests has been tested in the severest manner, for I am informed by Mr. Matthews that in 1860 a considerable tract of land extending from the vicinity of the furnaces at Káládhúngí to the base of the hills was cleared, no trees being left for bearing seed; and now (1873) the whole area is so covered with well grown saplings that it is difficult to believe in the accuracy of Mr. Matthews' statement.

Comparing the conditions now with what they were ten years ago, when the Kúmaon Iron Company stopped operations, circumstances are much more in favor of the possibility of Indian-manufactured iron competing with home produce. The high price of coal in England has led to such an advance in the cost of iron of all kinds that there is now a prospect of India being able profitably to work her own raw material.

NOTE ON THE RAW MATERIALS FOR IRON SMELTING IN THE RÁNIGANJ FIELD, BY THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

As a result of Mr. Bauerman's preliminary report upon the iron-ores of the Ràniganj coal-field, the Geological Survey of India has been called upon for information on the subject.

Claim of the field recognised.—It is almost needless to say that the claim of this field to be considered the most advantageous position for the manufacture of iron in Bengal on an European scale was recognised years and years ago by the Survey, and that Mr. Bauerman, in recommending it as the locality offering the best prospects of success, has but confirmed the opinion held by every geologist and others competent to offer one.

The establishing of large iron-works was not urged at the time of the survey of the Ràniganj field, for it would have shown an utter disregard of the conditions essential to success to have done so. Since then, however, increased facilities of communication, discoveries of better coals, the possibility of making coke, and the steady rise in the price of imported iron, have tended to reduce the margin of probable failure to such proportions that the prospect of the successful manufacture of iron has emerged from the region of speculation. Nevertheless, the caution recommended by Mr. Bauerman to the Government of India before going into any projects for the erection of works is very judicious; it being undeniable that the subject of fluxes is a most essential point to enquire into.

Kunkur assays.—With a view to throw some light upon the application of *kunkur*, I have lately made a few trial assays at the Mint which I will refer to in detail farther on. I obtained a very fair slag; but it must be remembered that the assays were conducted under a favourable combination of circumstances unattainable in a furnace, and that before the practical adaptability of kunkur can be pronounced upon, experiments on a more extensive scale ought to be carried out. The result of the small trials in so far answers a useful purpose, that it indicates a possible substitute for rock-limestone, and can be accepted as some measure of the value of kunkur.

Proposed trials.—I propose at the end of the field-season operating upon a few tons of raw material, varying the proportionate quantities of kunkur, ore and coal; and I cannot but anticipate that the deductions from such experiments will be useful. I am happy to say that I have already received offers of assistance and the loan of a cupola from Hon'ble J. M. Robinson, of the Bengal Coal Company, and Colonel H. Hyde, R. E., to the latter of whom I am already indebted for facilities afforded me at the Mint during my preliminary assays.

Although my more special attention was directed to the subject of fluxes, I was in addition instructed to point out the most favourable position for erecting furnaces; to institute enquiries about furnace materials; to make some sort of estimate as to the quantity of iron-ore available; and to confirm or modify the opinion entertained of certain coals in the western part of the field. For the sake of convenient reference I propose to notice each section of my enquiry under these different heads. And first as to coal.

COAL.—I presume it is unnecessary to adduce evidence in proof of the enormous amount of coal which exists in the Ràniganj field. There is perhaps no area of similar size in the whole world which can compare with it for actual thickness of the seams. The coal, however, is not so good in quality as it might be; but I believe better will be discovered as the field becomes progressively developed.

Weak point of Indian coal: its ash.—The weak point of our Indian coal is the amount of inorganic matter that it contains as compared to good English and Welsh coal; but lately two samples have been received at the Geological Survey Office, one from Sánpúr near Nirsha, and the other from Báhmandihá, near Niámatpúr, which contain only 8·9 and 8·7 per cent. of ash respectively. The average percentage is 15.

Nothing more than an ordinary analysis of these coals has been made, and their composition is—

	Sánpúr.	Báhmandihá.
Carbon	64·3	57·8
Volatile matter (inclusive of water) ...	26·8	33·5
Ash	8·9	8·7
	100·0	100·0

Both are said to coke; and as they are remarkably clean, they ought to be brought more into use. At present I believe they are scarcely worked. The Sánpúr coal is burdened with a cartage freight of six miles and a toll; but the Báhmandihá seam has no serious drawback to contend against. It lies in the general strike of the Sanktoria seam, which is well known to be one of the finest properties in the field, and it may be the continuation of that bed to the north-east.

A very complete series of analyses of thirty different coals has lately been made by Mr. Tween under Dr. Oldham's direction, and I find that those samples furnished by the Dúmarkúndá, Banáli, Sanktoria, Mangalpúr, and Ráníganj collieries combined the greatest freedom from ash with high percentage of carbon.

Names of Collieries.	Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Percentage of coke in undried coal.
Dúmarkúndá	71·86	4·67	8·78	·69	14·0	76·8
Sanktoria ...	68·89	4·52	12·27	·82	13·5	71·6
Ráníganj ...	69·45	4·82	10·98	·35	14·4	72·2
Banáli ...	69·08	4·79	10·00	·37	14·8	
Mangalpúr...	68·81	4·8	12·11	·88	13·3	

The loss of water in the Dúmarkúndá, Sanktoria, and Ráníganj coal was 2 per cent., in the Banáli coal 4 per cent., and in the Mangalpúr coal 5·8 per cent.

Amount of sulphur small.—The amount of sulphur is in each instance considerably under 1 per cent.—a fact which will not readily be credited by those who think that Indian coals are always saturated with iron-pyrites.

I append a statement of the amount of sulphur in some good class British coals:—*

	Sulphur in 100 parts of coal.
NORTHUMBERLAND.	
Steam Burn coal (steam coal)	·55
Peareth coal (gas coal)	·86
Low main seam, Buddles Hartley colliery (steam coal) ...	1·51
NOTTINGHAMSHIRE.	
Shircoak colliery, belonging to Duke of Newcastle ...	·92
SOUTH STAFFORDSHIRE.	
Rooves	1·00
LANCASHIRE.	
Bushey Park seam	1·01
Pemberton yard	1·82
BLAINA, SOUTH WALES.	
Ellvein coal (steam coal)	·75
Three quarter vein (furnace coal)	·81
DOWLAIS, SOUTH WALES.	
Ras Las	1·01
Bargoed big-coal (blast furnace coal)	1·07
SCOTLAND.	
Argesline	1·23
Walls end Elgin	1·51

* Percy's Metallurgy, 1861, Vol. I, pages 99, 102.—Crookes and Röhrig, 1870, Vol. III, page 469.

Reverting to the Ránigaṇj coals, the following is the result of the analyses of their ashes, and for the sake of illustration I subjoin a selection of a few Welsh and Scotch coal ashes:—*

	Silica.	Alumina.	Oxide of iron.	Lime.	Magnesia.	Sulphuric acid	Phosphoric acid.
Dúmarkúndá	60·54	31·0	6·52	1·21	·94	·55	·54
Sanktoria	58·00	29 03	7·49	3 26	...	1·11	1·46
Banáli	62 77	30·48	3·32	3·18	...	·47	1·2
Ránigaṇj	61·41	28·84	5 31	3 18	...	·52	·35
Mangalpur	59·66	26·72	8·08	2·92	...	1·2	1·18

	Dowlais.	Dowlais.	Dowlais	Dowlais.	Poutypool rock vein coal.	Ebbw vale four-feet steam coal.	Fifeshire Fordel splint coal.
Silica	35 73	24·18	37·61	39·61	40·00*	53 00	37·60
Alumina	41·11	20 82	38·48	30·20 }	44·78	35·01	52 00
Sesquioxide of iron	11 15	26 00	14·78	11·84 }			
Lime	2·75	9·38	2·53	1·81	12·00	3·94	3·73
Magnesia	2 65	9·74	2·71	2 58	Trace ...	2·20	1·10
Sulphuric acid	4·45	8·37	0·20	Traces ...	2 22	4·89	4·14
Phosphoric acid	0·99	0·21	2 00	3·01	0·75	0·88	0 88

It will be seen that the proportion of phosphoric acid in a hundred grains of the ashes of some of our Indian coals compares favourably with the English equivalents; but we must bear in mind that Indian coal is burdened, as a rule, with three to four times the amount of ash in English coal; and consequently for equal weights of coal the comparison is not so favorable.

Sanktoria coal caking.—Only one of the five selected coals, that of Sanktoria, is truly caking; the rest yield nothing better than bastard coke. Analysis shows that the Dúmarkúndá coal is a first class Indian coal; and I believe that it would produce a very fair description of coke provided the ovens were charged with freshly raised material.†

* Percy's Metallurgy, 1861, Vol. I, page 106.

† Since writing the above I have received from Colonel Hyde, R. E., a table showing the relative heating power of the several coals submitted for trial at the Mint; being of the same samples as those analysed in the laboratory of the Geological Survey by Mr. Tween. The Dúmarkúndá coal occupies the seventh place in a list of thirty.

Name of Colliery.	Heat units utilised per lb. coal.	REMARKS.
Ránigaṇj	9,788	Upper coal measures.
Babúsol	9,732	" " "
Nimcha	9,651	" " "
Sanktoria	9,622	" " "
Dhasal seam, Chowkidánga	9,584	" " "
Berodakatta	9,552	" " "
Dúmarkúndá	9,493	Lower " "
Mangalpúr	9,144	Upper " "
Sitárámpúr	9,013	" " "
Nigiá	8,962	" " "
Banáli	8,846	" " "

I cannot find any reference to the coal from the Belrúi colliery, but it deserves mention, as it cakes well, and looks bright and clean. The Belrúi seam, like the Báhmandihá, is on the same strike, and is possibly on the same horizon as the Sanktoria seam. In our present state of knowledge, one can only conjecture that such is the case; but an air of probability is lent to this opinion by the circumstance that the Belrúi coal possesses nearly the same qualities as the Sanktoria coal.

Freedom from ash important in connection with amount of flux required.—I have particularised the coals from eight different localities, because analysis shows that they are best adapted for smelting purposes. They are the coals freest from ash, and this is a point that must be borne in mind in connection with the amount of flux that will be required. For raising steam and for smithey works there are twenty other coals in the Ráníganj field that would answer nearly as well; and there is always the prospect that many of the collieries from which moderate or inferior coal is at present being raised may some day meet with better seams as their workings become deeper and new ground is opened out.

Best locality for coal.—The portion of the field which contains the most promising coals, east of the Bárákar, is decidedly that part of it limited in a north-west direction by the outcrop of the seams mined on the Sanktoria and Belrúi properties, and in a south-west direction by the Panchet formation marked on the geological map. Within this area is included, in addition to the collieries belonging to the Bengal and New Bírbhúm Companies, those owned by Messrs. Apcar and two or three quarries possessed by natives. Some of the land is, I am informed, held by Rani Sarná Móui, a Hindoo lady, whose religious principles are opposed to coal mining.

IRON-ORE.—The deposits of iron-ore are of two distinct geological ages. The older are associated with the coal measures, as a group in the series, while the more recent are connected with the rock known as laterite.

Laterite, as a rule, is not rich in iron;* and as it does not occur in any form west of the meridian of the town of Ráníganj, I directed my attention principally to the ores of the coal measures. I did not restrict my observations to any one special locality: I visited the lands east of Básórá, and Madápúr, and the entire tract from Lalganj to Bagunia. I thought it possible that the Singaran valley might be a good locality for iron works; but it does not offer the same advantages as the western part of the field, where the iron-ores of the measures are in close proximity to the superior coals of Sanktoria, Belrúi, Dúmarkúndá, Báhmandihá, &c.

The only samples of ore that I considered it necessary to collect were from the lands of Aítura, Malákola, Chalbalpúr, Kúlti, Sibpúr, Jassaidih, Boldi, and Notanghar. They are fair representative specimens picked mostly from heaps, which had, conveniently for me, been collected by the contractors who supply ballast for the repairs of the Grand Trunk Road.

Mr. Tween has up to the present time only been able to complete the analysis of one sample. It came from Kúlti, and contains—

1.	Insoluble matter (silica 16·4)	19·6
2.	Sesquioxide of iron (metallic iron 42 per cent.) ...	60·4
3.	Alumina	5·8
4.	Lime	2·9
5.	Magnesia	·6
6.	Phosphoric acid	2·2
7.	Water	9·2
		100·7

* Laterite usually contains from 12 to 25 per cent. of iron. Some of it, however, is nothing more than clay with iron stains.

There is no sulphuric acid, but there is an appreciable quantity of phosphoric acid.

Ore hæmatite.—I was rather surprised at the absence of carbonic acid, being under the impression that the above specimen was a carbonate of iron. It appears, however, to be a sesquioxide. The amount of iron it contains is 42 per cent., which makes it a valuable ore.

The ironstones occur over an area of several square miles in thin beds varying in thickness from 2 to 8 inches, through a mass of carbonaceous shales, known geologically as the ironstone shale group. Mr. Blanford* estimates that they form about $\frac{1}{14}$th of the whole group; and Mr. David Smith† considers that 6,400,000 tons per square mile will be the yield. My own measurements showed that the ironstones occurred in the proportion of 1 foot to 10 or 12 of shale, and taking the group as 1,000 feet (it is more than this), we have, roughly speaking, 200 millions of tons in every square mile. Assuming 5 feet only as workable, I think the figures will be assuring enough to set at rest all misgivings about quantity.

Small dip.—The dip of the strata with which the ironstones are associated is everywhere small in the neighbourhood of the Bárákar; and the contour of the surface is such that the conditions for mining by open work are all highly favourable. No difficulty can be experienced in winning the ore at a reasonable price.

Magnetic iron.—The advantage to be derived from mixing different varieties of ore is well known. Some very rich deposits of magnetic iron-ore are described by Mr. Blanford‡ as associated with metamorphic quartzites just beyond the boundary of the field near the village of Tituri, about two miles west of Beharináth hill. The ore occurs interlaminated with the quartzite and gneiss in bands varying in thickness from 3 inches to 2 feet. They are very pure, and contain from 60 to 70 per cent. of iron. Research may bring to light other similar deposits; but there is little probability of such a thing happening, as the natives are usually aware of the iron-ores that occur in their own district, and if any had existed, information about them could hardly have escaped the frequent inquiries that have been made

The main dependence of any iron works must be upon the iron-ores of the coal measures.

FLUX.—As I have not been called upon to compile a treatise upon the manufacture of iron, I need not explain why the necessity for a flux exists. Many minerals might be used as fluxes, but in practice we are limited to a few, namely, limestone, clay, and silica. For such ores as occur in the Ránigánj field, limestone is most required; and limestone that is nearly pure has hitherto been considered as indispensable.

Impure limestone sometimes preferable.—In some instances, however, as in the case of the Kùlti ore, the analysis of which has been given above, a limestone containing some clay would be preferable. Impure limestone indeed is often advantageous, but its applicability depends upon the suitability of its own impurities to combine with those of the iron-ore.

In kunkur we have an impure limestone, containing from 70 per cent. downwards of carbonate of lime, and a varying proportion of free silica, clay, magnesia, iron and water. It would make in some instances a most economical flux if the amount of carbonate of lime in it were somewhat greater than it is. Kunkur, as a rule, however, rarely contains more than 60 to 65 per cent. of carbonate of lime, which leaves a large amount of impurity, out of which some is probably not required, and therefore it subtracts from the working value of the kunkur.

* Memoirs of the Geological Survey of India, 1861, Vol. III, Art. 1, page 76.

† Mr. David Smith's report on the coal and iron districts of Bengal, 1856, page 6.

‡ Memoirs of the Geological Survey of India, 1861, Vol. III, Art. 1, page 193.

Some specimens which I obtained in the Ránigan field contain the following quantities of carbonate of lime:—

Sanktoria ...	...	...	...	66·12 per cent.
Rámnagar...	...	...	...	64·98 „
Barmúri ...	...	...	...	61·00 „

Mr. Tween has not been able to make a full analysis as yet of all the samples that have been sent in for examination, and without such analysis, it is impossible to estimate what proportion theoretically the kunkur should bear to fuel and ore, in order to produce a suitable slag.

Well fused slag and clean button.—I have, however, carried out some assays at the Mint; and the result is, that with equal quantities of kunkur and ore, and using wood charcoal or coke, I obtained a well fused slag and a moderately clean button of iron. I have not made the number and varieties of assays that I should like to, owing to the necessity of sending in a report at an early date; but the possibility has been demonstrated of using kunkur as a flux on a small scale.

The assays were performed in unlined plumbago crucibles. My first experiment was unsuccessful, as I could not get up heat enough in the small table gas furnace which Colonel Hyde placed at my disposal. My after attempts with the use of coke in a wind furnace were more fortunate.

No. 1.	Ore ...	...	100 grains	(Kúlti ironstone containing by wet assay 42 per cent. iron).
	Kunkur	...	100 „	(Rámnagar kunkur containing 65 per cent. carbonate of lime).
	Charcoal	...	30 „	(Wood charcoal).

Percentage of iron 45·0; slag perfectly fused, grey. Button of iron, dark-grey, crystalline, broke rather readily under hammer. Two or three sorts of metal embedded in the slag.

From the appearance of the iron, the ore will probably reduce easily.

No. 2.	Ore ...	...	150 grains.
	Kunkur	...	150 „
	Charcoal	...	40 „

Percentage of iron 44·7; like all dry assays, the percentage of iron is shown to be greater than it actually is. Slag, greyish-green, a few beads of iron adhering to outer surface. Button, dark-grey on fractured face. Does not split at first blow, but flattens somewhat.

No. 3	Ore ...	...	100 grains.	
	Kunkur	...	100 „	
	Coke ...	...	30 „	(coke from Calcutta gas works).

This was put into a smith's fire, and the slag was not perfectly fused. It had a light green colour. Numberless shots of iron at bottom of slag. Fractured surface of button, white.

No. 4.	Ore ...	...	100 grains.	
	Kunkur	...	100 „	
	Coke ...	...	30 „	(coke from Calcutta gas works).

Slag, light grey, semi-translucent. Button on fractured face, white, compact.

No. 5.	Ore ...	...	150 grains.	
	Kunkur	...	150 „	
	Coke ...	...	40 „	(coke from unwashed Sanktoria coal-dust).

Slag, light amethyst colour, clear, translucent. Button, on fractured face, dark-grey, coarsely crystalline. The amethystine colour of the slag may be due to manganese.

No. 6.	Ore ...	...	150 grains.	
	Kunkur	...	130 „	
	Coke ...	...	30 „	(coke picked piece of Sanktoria coke).

Percentage of iron 44·0. Slag, slight amethyst colour, translucent. Button on fractured surface, not quite so dark as No. 5, coarsely crystalline.

I made several other assays which I need not refer to. My object was to see whether kunkur would do the work that was required of it. The less quantity, 130 grains in No. 6, answered quite as well as 150 grains in No. 5; but I would recommend equal quantities of kunkur and ore, because the coke contains sometimes a large amount of ash.

I have used throughout only the same flux that could be employed on the large scale. Pure limestone is not known to occur in any quantity in or near to the Rániganj field. My colleague, Mr. Mallet, however, has discovered a bed of it in the vicinity of the Madápúr Branch Railway; and it is quite possible that when investigations in that neighbourhood can be completed more may haply be discovered. The limestone is very pure, and is only ten miles from the station, so that if railway rates for carriage were only cheaper, it might be employed to supplement the kunkur of the Rániganj field. A large quantity might easily be removed. I have been informed of another bed south of the Damúdá and near to Ránigan; but I have not yet had an opportunity of visiting it. From the appearance of the sample sent to me for examination, I scarcely think that it can be of much importance.

It is not to either of these limestones, however, that we can look for a supply of flux; and Rotás stone is so dear comparatively to kunkur that I think we must depend upon the latter material.

Amount of kunkur.—On the question of the quantity of kunkur available within the field, I have consulted with Mr. Dejoux, Executive Engineer, who is at the head of the Special Department devoted to lime, kunkur, and limestones, and he assures me that there is an unlimited quantity. In this assurance Mr. Joll, who was for some time Executive Engineer at Bárákar, unites. Mr. Dejoux's experience and special knowledge is so much greater than my own that I prefer quoting his conviction to offering a decisive opinion of my own. I examined several of the localities where lime was being made, and judging by what I saw, I am inclined to think that there are very large deposits in the vicinity of Bárákar; both banks of the river are full of kunkur; and the quality of the material appears to improve at some depth below the surface.

One advantage that would be derived probably from the use of Rotás limestone is, that its average composition might be depended upon. As regards kunkur, I am not sure whether this would be the case. Again, quoting Mr. Dejoux, however, he says that out of numerous samples which he has analysed, he has found that its composition is much more constant than might be anticipated from the nature of its origin, and that 55 to 65 per cent. is the usual amount of carbonate of lime that it contains. If this be so,—and the analyses now being made in our office will confirm or disprove this point,—we shall be able to regulate the amount required for fluxing; but if the percentage of carbonate of lime be inconstant, the working of a furnace is likely to be variable and the outturn of iron irregular both in quality and quantity.

I trust I have made clear the case regarding kunkur: 1*st*, that there is a large quantity available; 2*nd*, that it can be used as a flux; but that unless its composition be pretty constant, there are difficulties in the way of its employment that might make the use of a more costly but a more reliable limestone advantageous.

Until full analyses of many specimens have been made however, we cannot pass judgment. Should they prove the composition of kunkur constant between certain limits, then I think we may, without actual experiments on the large scale, declare it to be an appropriate flux.

CHOICE OF SITE.—The tendency of the evidence brought forward has been to show that the country in the vicinity of the Bárákar is best adapted for a site. No locality offers the same advantages. It is nearer to the foreign sources of limestone at Rotás and in the Hazáribagh district than any other part of the field. The best quality coals occur there; easily workable ores may be got; an abundance of kunkur can be procured; sandstone quarries are in actual existence; the Grand Trunk Road, and the Bárákar branch, and Chord Line of the East Indian Railway are in the immediate vicinity of all requisite raw materials; and the land necessary for buildings, tipping room, &c., belongs, in great part I believe, to native holders, who would probably dispose of it at more favourable rates than British holders.

Any definite selection of a site must of course be postponed for the judgment of the manager who may be appointed, but the choice ought to be limited between the meridians of the Sítárámpúr and Bárákar Railway stations, and a short distance north or south of the Grand Trunk Road.

FURNACE BUILDING MATERIALS.—It is difficult to say off-hand whether certain stones will have the property of sustaining the temperature which the chemical process carried on in the furnace requires. In the selection of native stones, as also of artificially manufactured stones, we must be guided chiefly by experience. There are quarries near the Bárákar bridge, from which the sandstone of the lower coal measures are obtained, and if those that are fine-grained are selected, they will probably be found to withstand heat and the action of fluxes.

Soapstone.—Occurs in the Manbhúm district, and dishes made from it used formerly to be sold at Taldángá; source of supply is rather distant.

Fire clay.—Scarcely any attempt has hitherto been made to turn the fire-clay, which is found with many of the seams, to account. Messrs. Burn and Company, who possess pottery works at Rániganj, have lately made a few bricks from the clay in the Rániganj colliery of the Bengal Coal Company, and the manager, Mr. Cowhan, informed me that they were tested at Jamálpúr, and were found to withstand the treatment they were subjected to much better than English bricks. I believe fire-clay occurs at the Baséra colliery of the Ránigauj Coal Association, but it has not yet been tested.

Coarse sand.—This is required for mixing with other materials. It can be obtained from the rivers Bárákar and Damúdá.

Quartz.—This, like the above, may also be wanted for mixing. Large quantities are procurable a short distance up the chord line, about Jamtarah.

Moulding sand.—Some moulding sand of very pure quality is obtained near Ránigauj from the Damúdá. I know of no other place where it occurs, but equally good sand may possibly be found in the Bárákar.

CONCLUDING REMARKS.—Having shown that the materials essential for the manufacture of iron exist, I will now point out what the probable cost of coal, iron, and kunkur per ton will be.

Coal.—A very fair estimate is Rs. 2-8 to Rs. 3 a ton.

Iron-ore.—The price of ore delivered at the works will probably be Re. 1 a ton. The rates at present paid by the contractors who obtain ore from the Kúlti estate of the new Bírbhúm Coal Company is only 5 annas a ton, or Rs. 1-8 per hundred cubic feet loosely heaped; but as the ore is close to the surface, I have trebled the rate in order to cover extra expenses when deeper workings are opened out. Any information about the rate paid for assistance, although imparted to me by a contractor's Sirdar, may not be correct, as natives sometimes make misstatements. Whether this be so or not however Re. 1 a ton is a liberal estimate.

Kunkur.—This material ought to be procurable at Rs. 1-8 a ton, or Rs. 5 a hundred cubic feet.* Mr. Joll, Executive Engineer, roughly values unwashed kunkur at Rs. 1-6 a ton. In order to be on the safe side however, let the rate in all calculations be Rs. 2. I find that Rotás limestone, taking the very lowest estimates, will for equal quantities be exactly ten times the cost of kunkur when delivered at Sítárámpúr.

Thus, 100 cubic feet of limestone conveyed from Rotás to Lakiserai by water the whole way ...	Rs.	18	0	0
Railway freight from Lakiserai to Sítárámpúr	„	47	0	0
Unlanding and landing charges, and so on ...	„	5	0	0
Total ...	Rs.	70	0	0

or Rs. 20 a ton as compared to Rs. 2; but as Rotás limestone will probably do three times the amount of duty that kunkur will, the comparison is as Rs. 6 to Rs. 20. Considerable advantage would be derived from the use of Rotás or any other comparatively purer limestone, because in the employment of kunkur, there is an increase in the weight of material to be passed through the furnace for the same produce of metal.

Occasionally, as I pointed out before, an impure limestone may be more suitable for a flux than a pure one; but in kunkur the impurities are somewhat too great, not to make it advisable, bearing in mind relative cost, to substitute a better material.

Cost of manufacture.—The simple cost of the manufacture of pig-iron per ton, leaving out of consideration the interest on cost of furnaces, management, and so on, will, according to my figures, be—

			Rs.	A.	P.
Ore ...	$3\frac{1}{2}$ tons at 1	... ...	3	8	0
Kunkur ...	$3\frac{1}{2}$ „ at 2	... ...	7	0	0
Coal (large) ...	$3\frac{1}{2}$ „ at 3	... ...	10	8	0
Coal (small)	... ...	... ...	0	8	0
Wages	... ...	... ...	2	8	0
			24	0	0

I have allowed liberally both in the amount of material and in the matter of cost. Mr. David Smith, who made very careful calculations in 1856, showed that with the price of home manufactured iron as it then ruled, and with the estimated cost of pig-iron at Rs. 20-8 per ton,† there would be a considerable profit. I think there can be but little doubt

* The ton is calculated as 27 "*mans.*"

Iron-ore	100 cubic feet = 135 *mans* = 5 tons.
Kunkur	100 „ „ = 94 „ = $3\frac{1}{2}$ „
Limestone	100 „ „ = 94 „ = $3\frac{1}{2}$ „

† Mr. David Smith's report on iron districts of Bengal, 1856, p. 19. His figures are for simple cost of manufacture as mine are.

that if there is demand enough in Indian markets, iron may be manufactured in this country and sold at a much cheaper rate than imported English iron can be bought for.

There are always difficulties inherent in the starting of new undertakings; but we have the beacons of past failures in other parts of India to steer our way by. If any of the Companies at Ránigaṇj who possess their own coal, iron-ore, and kunkur were to take up the project of iron smelting, they would have immense advantages over Government in respect of cost of raw materials; should, therefore, the present attempt be in the least degree successful, it will be a guarantee to all Companies of the value of their own resources.

THEODORE W. H. HUGHES.

NOTE ON THE HABITAT IN INDIA OF THE ELASTIC SANDSTONE, OR SO CALLED ITACOLUMYTE.

Although within the last twenty years members of the Geological Survey have frequently passed within sixty miles of this interesting locality, no one has been able to visit it—so great is the difficulty and loss of time involved in making the shortest excursion off the main highways in India. At last an amateur has come to the rescue; and it is to be hoped the example will be followed elsewhere, for official geologists, having to work by rule and measure, can rarely supply the place of the genuine amateur in the repeated contemplative observation of local conditions. Geology has boasted of several distinguished and devoted amateurs in India. The recent comparative scarcity of such labourers must be due to the greatly increased activity of official life, and not to any growing distaste for recreation in scientific pursuits. Colonel McMahon, Commissioner of Hissar, has sent a box of specimens and some very interesting notes illustrative of the only known position of the elastic sandstone. The description is given as far as possible in his own words.

Kaliana is five miles west from Dadri, a town in the Jheend state, sixty miles nearly due west from Delhi. The hill, which is one of the Trigonometrical Survey Stations, is 1,477 feet above the sea, and about 740 above the plain. It consists of a long ridge, running for some miles in about a north-north-east direction; one of the many such ridges which in this region of the Punjab stretch far into the plains, the alluvial areas between them being confluent with that of the Indo-gangetic deposits. These ridges are prolongations of the Aravali mountain system, and are approximately on the line of the Indo-gangetic watershed. The ridge of Futehpur Sikri, running north-north-east to within a few miles of Agra, is the most westerly member of the Aravali system of disturbance; it is formed of up-turned Vindhyan rocks, being the western limit of the great spread of these ancient deposits, stretching from here round by Saugor to Sasseram in Behar. In examining the ground to the west of Agra, the Survey geologists have been a little puzzled by the position of the elastic sandstone; this name, and the superficial appearance of the stone, leading one to expect a recurrence of some unaltered rock-group, perhaps an outlier of the Vindhyan series. It is an excellent illustration of the way in which deeper geological meanings become attached to words based originally upon superficial characters, involving of course a reciprocal restriction of the extension or denotation of the term. This stone is in reality only a very local and modified condition of a massive quartzite, which is the general name for metamorphic sandstones.

The highest part of the ridge immediately overhangs the village of Kaliana. It is here double-crested, the projecting ribs being formed by two strong beds of ironstone, a quartzite strongly impregnated by massive specular iron (black hæmatite) and some magnetic iron, strings of pure ore occurring locally in the mass. These bands of ferruginous quartzite are regularly interstratified with the mica and hornblende-schists; and the earthy cellular quartzite so largely quarried for millstones is distinctly an intercalated member of the same series, all being nearly vertical. The elastic sandstone is only found in patches in this band of millstone quartzite. There is no regular bed or seam of it; the stone-cutters, of whom there is quite a colony at Kaliana, come upon it suddenly when cutting out slabs of the ordinary stone. Often the rock in immediate contact with a nest of elastic sandstone is highly indurated and quartzose. The stone-cutters declare that they sometimes find it in the line of the bedding, and sometimes along the joints. Their idea of the matter is, that it is a mere local peculiarity of the sandstone rock caused by the percolation of rain water and *miti* (earth) from the surface. If the *miti* had been omitted, the native explanation is probably the correct one. The only superficially noticeable difference between the two is the greater porosity and friability of the elastic stone, owing probably to the removal of some thinly permeating cement to which the strong rigidity of the quartzite is due. Among the rocks sent by Colonel McMahon there is a variety of this pseudo-metamorphic rock in which the earthy ingredient prevails largely over the quartzose. Its aspect is somewhat like that of a half-baked fire-brick; and it would seem as if it had only needed a modicum of some alkaloid base to have converted the whole into a form of gneissic rock.

There are two myths connected with these elastic sandstones which it is desirable to discredit. One is its supposed connection with diamonds. In India at least there is no shadow of such connection. All the widely scattered diamond localities seem somehow connected with members of the Vindhyan series of rocks. And, on the other hand, there is no tradition of diamonds at Kaliana. The idea comes from Brazil, whence also the fancy name Itacolumyte; it is probable that the connection is quite imaginary.

The other notion is, that the elasticity is attributable to talc, or mica. However this may be true of the Brazilian variety, there is no pretence for it in the Kaliana rock; the few small plates of mica in it are quite isolated, the rock not having any schistose (foliated) structure. The only tenable account of this property of elasticity is that given by Professor Haughton, whose name is a full guarantee of correctness:—"A most remarkable circumstance sometimes occurs in the formation of these sandstones, which are not composed of pure particles of quartz, but of clay mixed with them, namely, that the particles of quartz mixed in this clay or paste are permitted a certain amount of motion. If you take an ordinary sandstone, it is like any other rock; and with a lens you can see the separate particles, and that each separate particle is touched on every side by a number of other rounded particles that hold it in its place, and it in turn contributes to hold them in their places, so as to form of the whole a rigid rock like any other. But, occasionally, in some rare cases—which, as far as I have any knowledge of them, are confined to Brazil, South Carolina, and Delhi—you have a rock composed of particles of sandstone, which are not in contact with each other, but lie in a paste of felspathic clay, which paste permits a certain amount of motion between the particles of the mass." (Haughton's Manual of Geology, Lecture II, p. 51). It would seem that in the Kaliana rock, doubly metamorphosing conditions were concerned in its production—a solidifying process to give tenuity to the earthy paste, and a partial dissolution to remove the rigidity of its first solidification.

Elasticity, in its vernacular sense, is a misleading name for the character of this stone. It bends without the least sensible increase of resistance up to a certain limit, where it comes to hard stop. Mr. F. R. Mallet found that a slab of the Kaliana stone 24·5" × 6·7" × 1·8", resting on supports 24" apart, gave a deflection of 0·7"; and that after saturation with water the deflection was reduced to 0·65.

On the west side of the Kaliana hill and not far from the top there is an old mine cut into the ironstone. It is said that three generations ago it was worked for copper. In a piece of schist sent from this spot, there is not the slightest trace of copper staining; but the mica has a very decided copper colour, which may have been the beginning and end of the mining experiment.—H. B. M.

GEOLOGICAL NOTES ON PART OF NORTHERN HAZÁRIBÁGH, *by* F. R. MALLET, F. G. S., *Geological Survey of India.*

In an early number of these Records (Vol. II, p. 40, 1869,) a brief notice was given of the metamorphic rocks of Bengal, in the northern part of their area, from the Karakpur hills at the north-east corner of the rock-area of the Peninsula, along the lower valley of the Ganges and the Són valley, into the valley of the Narbada, where all the older formations pass under the Dakkin trap. Throughout that distance, in a west-south-west direction, and corresponding with those very marked orographical features, the gneiss is fringed by less metamorphosed rocks—schists, slates, and quartzites. To give shape to the study of these rocks, more than from any compulsion of decided views, a tentative classification was then attempted, upon general stratigraphical reasoning, occasionally against the apparent (*primâ facie*) evidence of local sections. The series thus indicated consisted in chronological order of—1*st*, a fundamental gneiss (undiscriminated); 2*nd*, gneissic schists and quartzites (of Mahábar) corresponding to the less metamorphosed slaty schists and quartzites to the north (Rájgir); 3*rd*, massive gneissoid (foliated) granite, mostly forming domes; 4*th*, flaggy schists and gneiss with quartzites and amorphous pseudo-gneiss, sometimes conglomeritic (Lakisarai, Betia, Sukri, infra-Bijáwars of Bandelkand); 5*th*, intrusive invasion of pegmatite; 6*th*, Bijáwars (of Bandelkand and the Agori zone of the Són valley).

The hazardous points of this scheme were known to be—the doubtfully granitic (exotic) character of any of the dome gneiss, and principally, the supposition of gneissose rocks (No. 4) greatly younger than the schist and quartzite series (No. 2). Both positions were placed primarily upon the same general evidence—the universally intense folding, with cleavage of the schist and quartzite series, compared with the frequently moderate disturbance in a portion of the gneissic rocks, which, moreover, seemed to occupy a position of general superficiality as regards the main body of the gneiss and to contain locally débris of the quartzite series.

The detailed survey of which these notes are a first instalment was undertaken in the hope of working out some more definite views upon rocks forming so broad a feature in the geology of India. The observations refer to what seemed to be a key to the position, where the schists and quartzites of Mahábar are well exposed in connection with the gneiss. The area especially referred to is contained in sheets Nos. 7 and 8 of the new topographical survey of Hazáribágh district, on the scale of one-inch to the mile, of which sheets this note may be taken as a description; some observations, however, referring to the adjoining ground where the geological mapping was incomplete. As the survey of this region has been interrupted by orders of Government, in order to take up the examination of some supposed coal-bearing ground at the base of the Eastern Himalaya, it is well to make a record of the work so far done. Thus far the views suggested by the sketch-survey have not been upheld as applicable to the section here; the massive dome-gneiss, of which some magnificent examples occur, is not proved to be in any special sense intrusive, or foreign to the rocks with which it is associated; and the flaggy schists with quartzites of the Sukri seem to be an irregular basal member of the Mahábar series, rather than a much later and independent group; however this relation may still be maintained for the conglomeritic pseudo-gneiss of Lakisarai and Bandelkand.

Immediately to the south of the above-mentioned area (that included in sheets 7 and 8) spreads the comparatively level highland of Karrakdiha, the extreme edge of which invades sheet 8 in one or two places, as at Gajhandi and Simmeria. To the north again of the Mahábar and Bhiaura ranges, the alluvial planes of Bihár stretch to the horizon, save here and there where some outlying hill breaks the continuity of the prospect. The area under discussion, therefore, comprises a part of the jungly and hilly country which marks the descent from the open and cultivated **Hazáribágh** plateau to the Gangetic plains. This broken interval varies very much in breadth; in the south-west corner of sheet 8 we have **Sídwatánd** and **Bishanpur** respectively on the plateau and alluvium and separated by less than a kos, whilst from **Simmeria** some fifteen miles must be crossed before the alluvium comes in sight along the northern base of the **Mahábar** hills.

Only two prominent groups of stratified rock are present: the metamorphic composed mainly of gneiss, with runs of hornblende rock, and the submetamorphic* which is made up almost entirely of mica-schists and quartzites, with some hornblendic bands. It is scarcely necessary to say that the quartzites and the more granitiform varieties of gneiss form the highest and most imposing masses of hill, *e. g.*, the **Bhiaura** and **Mahábar** ranges, **Durbásha** and **Máramoko** Hills, whilst instances are not uncommon in which the lines of drainage have been scooped out of the softer schists, as in the western part of sheet 8.

METAMORPHICS.—Lithologically the gneiss presents few characteristics differing from the ordinary ones which have been so often described elsewhere. The actual gneiss itself is usually composed of felspar having commonly a red color, although sometimes white, quartz, and uniaxial mica in small dark green or black scales. Hornblende rock and schist are very abundant, varying in texture from a compact stony variety to one in which the foliation is very prominent. Subordinate runs of mica-schist also occur, some of which are composed of a mixture of black mica and hornblende with quartz, others of silvery mica with quartz; the latter variety is similar in appearance to some of the mica-schists of the submetamorphic series, although clearly interbanded with and passing into the gneiss.

Seldom are more perfect examples of the dome-shaped form of hill into which the gneiss sometimes weathers to be found than in the present area. Two cases are more especially prominent; the hills which run along the north side of the **Bhiaura** range and those which internally fringe the quartzite ridge north of **Gáwan**. In the former instance the domes extend from **Bélchaki** eastwards to north of **Dhubni**, the rock throughout being a very homogeneous† compound (viewed on the large scale) of white felspar, quartz and black mica, containing also ill-formed porphyritic crystals of similar felspar. Nearly vertical foliation is almost everywhere clearly marked, even on the smooth rounded faces of the hills, running parallel to the quartz ridge on the south. In the previous notice of these rocks already alluded to, while the foliated character of the rock forming the **Bélchaki** domes, and the absence of dykes ramifying from it into the adjacent quartzite, is noticed, the possibility of its being, notwithstanding, of a truly granitic character is suggested, partly on stratigraphical grounds and partly from the appearance of reaction of the rock in question and the quartzite on each other. My own more detailed examination, however, has led me to regard it as belonging to the metamorphic series. It certainly is more homogeneous on the large scale than the mass of the gneissose rocks; it does not include subordinate bands of other rocks such as hornblende or mica-schist. I think, however, that this is due, not to the homogeneous and the mixed rocks being distinct in origin, but to the fact (as I take it) that homogeniety is a necessary element in the production of the domes, and hence that it is only such portions of the gneiss as possess this homogeniety that weather into domes. The gneiss north-west of Churki for instance, and again at Pokriamo, is itself exactly of the **Bélchaki** type, but it is interbanded with layers and beds of hornblende schist, and in neither case have prominent domes been formed.

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* The prefix 'sub' is used here, as in previous papers in these volumes in the same connection, to denote an inferior degree of metamorphism, and has no reference to the stratigraphical position of the rocks in question.

† In the valley south of **Bélchaki** there is a low hillock formed of what I take to be hornblende rock, although possibly trappean. This is the only exception I have observed, and it is in the valley between the domes, not in the domes themselves.

Small veins of segregitic pegmatite, having the same composition as the surrounding rock, from which they only differ in largeness of crystallization, are not uncommon in the gneiss; they seldom exceed two or three feet in thickness, are sometimes short and lenticular, in other cases traceable for some little distance. It is sometimes not easy to distinguish these from the granite veins to be described further on.

Limestone.—Calcareous rocks are very rare in the metamorphics of this region. In fact I have observed none in sheets 7 or 8 except a thick band of dolomitic limestone at Dhelwa (north of Gáwan), which may, however, belong to the submetamorphic series, and a few thin layers of the same rock close to Gáwan.

In the bed of the Patru nadi, north-east of Gulgo, (east side of sheet 3) the following section is exposed:—

a.—Hornblende schist overlaid by

b.—Largely crystalline white limestone containing scales of light green mica here and there; this bed is about 6 feet thick, and is covered by

c.—A peculiar mixture of garnet and coccolite containing traces of galena and copper. In places the two minerals are well intermixed, in others the garnet occurs in a pure massive form (so called calderite); only a few feet of this rock (*c*) is seen.

The beds in this section, which is on the south side of the stream, dip at about 15° to east-north-east, and the same strata are seen on the opposite side also, the distance from bank to bank, or length of visible outcrop, being perhaps 50 yards. An analysis of the limestone by Mr. Tween yielded—

Carbonate of lime	88·80
" magnesia	3·07
Oxide of iron and alumina	·61
Insoluble	7·18
	99 66

The locality is worth notice, as being within fifteen miles of Mahishmon station on the Karharbári branch of the East Indian Railway, over a country traversable by carts; more especially so in the event of iron works being started at Ránigunj, the distance of which from Mahishmon is seventy-nine miles by rail. The bed is thin no doubt, but it may extend a considerable distance, and perhaps increase in thickness along the strike, and there is further the possibility of its being brought to the surface elsewhere in the neighbourhood by rolls in the strata. These points can only be determined by a close survey of the ground, which is beyond the limits of the area at present completed. A limited supply of very good mineral, either for burning or as a flux, can, however, undoubtedly be obtained there, whilst there is the possibility that if the bed were opened out, it would prove of considerable value. The nearest known locality where limestone occurs plentifully is Rhotásgarh on the Són, the transport of stone from which to Ránigunj would involve over eighty miles of river and 236 miles of railway carriage; a bed, therefore, like the above, although it may perhaps not prove to be of much importance, is still well worth a trial.

Lead-ores.—Galena is sparsely disseminated here and there through the garnet and coccolite rock mentioned above, as overlying the limestone; and minute specks of copper pyrites and blende are also visible, the rock in one or two places being stained bright green by copper.

On the north bank of the river the beds are cut through by a nearly vertical granite vein, which also contains traces of galena, and the felspar in which is partly amazonstone, the color being probably due to copper. Both lead and copper, however, merely occur very sparingly disseminated through these rocks. There is no indication of a lode, or any reason for supposing the ores to exist more plentifully in the vicinity. The locality was pointed out to me by the agent of the zemindar to whom the land belongs as one in which lead had been found. He had caused some excavations to be made in the hope of finding more, which I advised him to discontinue.

I was also informed that some loose fragments of lead-ore (cerussite apparently from the description) had been found loose on the surface of the soil just east of Mehandádi (sheet 3) about a year ago, and also to the south of the village; and that on digging in the latter locality some more was found two or three feet below the surface.

Cerussite was found by some Santháls, from one of whom I obtained a specimen, under similar circumstances at Barhamasia (sheet 3), some five or six years ago, and a small quantity of lead smelted from it, after which it appears they closed the hole up in order to keep the discovery a secret. About two years ago also a Sonár was looking for pieces of kankar, to make lime for pán, near the village of Nauwáda, south-west of Dhurgaon (sheet 9). On putting some pieces of what he supposed to be such in the fire in order to burn them, he was rather surprised to find globules of lead to have resulted from the operation. He then searched the locality for more, but failed in finding any at the time. In the rains, however, when the earth had been washed away from the loose surface-stones, he found a few pieces, aggregating about half a sír, from which he obtained a small quantity of lead. The ore in question is a dark red cerussite, like that of Barhamasia; and similar fragments are said to have been found close to Khesmi (sheet 9). In all these localities they probably indicate the existence of lead-ore somewhere in the vicinity, but not necessarily at the immediate spot, as they appear in every case to have been found either loose on the surface or embedded in the surface soil. They furnish no evidence of the presence of lead in workable quantity, although there is of course the possibility of the existence of such. It would perhaps be worth while to expend a small sum in examining the localities at Barhamasia and south of Mehandádi.

Tinstone.—Tin-ore was worked some years ago at Nurgo, a village just south of the Barákar and about three miles from Leda (eight miles west of Karharbári). The original discovery of the tin appears to have been purely accidental on the part of some Kols, who having dug up the ore and smelted it as one of iron, were surprized to see what they took for silver, flow from the tap-hole. They endeavoured to dispose of it as such at Rániganj, and there learnt its true nature. They then abandoned the pit, and after a few years the exact locality where it occurred was forgotten. Subsequently a Mr. Lord determined to work the ore, and after several trial sinkings succeeded in hitting upon the right spot.

The ore occurred in three or four lenticular beds or nests in the gneiss, the cross section being lenticular and seldom more than a foot or two across, although at one or two points as much as thirteen, while the nests extended over 20 yards in a direction nearly parallel to the foliation of the gneiss, from the outcrop to the limit of the workings. The gneiss (which is of a thinly foliated, rather rotten variety, including a few thin segregitic seams of pegmatite) dips at about 25° to E. 10° N., the nests consequently having a similar direction. The ore consisted of gneiss through which crystals and grains of tin were thickly distributed. Mr. Deveria, Mr. Lord's manager, followed these tin-bearing nests for about 20 yards by an inclined gallery;* the tin was then decreasing rapidly in quantity, while the rock was harder, and a large quantity of water draining into the mine; and hence the gross receipts being less than the working expenses, the mine was abandoned.

During the time it was worked, the ore after being brought to the surface, was broken up while still fresh (as it hardened considerably by exposure) with a common country dheki.

* My friend Mr. T. H. Hughes had an opportunity of seeing the mine when open, and it is from his notes that this brief account is given.

The pounded ore was then placed in a basket and washed by hand, by which means most of the lighter impurities, chiefly quartz and felspar, were removed. Subsequently after drying, it was sifted in a chop (winnowing basket) to separate the remaining sand. When a sufficient amount of ore had been accumulated, it was smelted with charcoal in an ordinary aguriá's furnace, the charges being the same as those used in iron smelting. The tin, after being run out and cooled with water, was broken up, the clean metal laid aside preparatory to casting, and the rest, which was much mixed with charcoal, returned to the furnace. The clean tin was re-melted in a large open iron vessel and ladled out into moulds, holding about 40 ℔s. of metal each. Altogether only about twelve maunds of tin was produced, as I was informed by a native of the place who had worked under Mr. Deveria.

Magnetic iron.—There are a few ferruginous bands scattered through the gneiss, containing a certain proportion of magnetic iron. I have not observed any very rich ores, although poorer ones are often smelted by the native "aguriás." Magnetite is also sometimes disseminated through the gneiss itself in small quantity, and collects in some of the stream beds to a trifling extent.

SUBMETAMORPHICS.

Relations to Metamorphics.—The difficult question of the relations between the metamorphics and submetamorphics is one which must eventually be decided by a review of the entire area, or at least of a large portion thereof, unless, indeed, we are fortunate enough to obtain some crucial sections which will prove a key to the solution of the problem. Such sections, however, are not available in our present ground.

Starting with the identification of the Mahábar schists and quartzites with those of Rájgír and Karakpur as suggested by Mr. Medlicott, we shall find that whatever may be the case elsewhere, there are no indications here of strongly marked unconformity to the gneiss. Taking, for instance, the line of junction between the quartzite and gneiss north of Gáwan, we see that it bends round successively from N. W. to N. E., E., S. E. and E. N. E., the strike of each rock being throughout parallel to the boundary; and not only do they agree in strike, but also in dip. Along the greatest portion of the above line the gneiss underlies the quartzite; but near Gáwan, and also at Hardíha, the reverse is the case (the strata here being inverted); throughout also, whether the dip be natural or inverted, it is equal in both at any given point.

Individual sections are also obtainable in which the same absence of unconformity is apparent. Thus, where the stream cuts through the quartzite ridge due north of Momankhitán, the last gneiss seen is well foliated, dipping 60° to N. 20° E., and composed of reddish felspar, quartz and schorl, the last being aggregated in places into large masses of crystals. Twenty yards lower down stream (higher in the section), and with similar dip, is granular quartzite composed of translucent grains; a little lower it contains small innate crystals of schorl and mica. Beyond this is more quartzite with a small included band of mica-schist, and the Dadho range is entirely of the latter rock. North-east of Birne, again, the gneiss is schistose, and the quartzite somewhat felspathic near the junction, so that the two rocks have the appearance of passing into each other within a few yards across the strike.

The same parallelism of strike is also observable on the large scale along the Bhiaura junction, from Bélchaki to Dhubni, in the dome gneiss. South-east of Belghati, however, the strike is not sufficiently regular to allow one to say whether, as a whole, it is parallel to that of the quartzite or not. The gneiss here is much mixed with hornblende schist, &c., and I do not think the beds are the same as those which form the domes. Here, then, is perhaps a case of unconformity, although it might also be explained by faulting.

Micaceous quartzite is again seen in the hills west of Manjne, being, I believe, the same as that to the east; but the junction with the gneiss is here somewhat different. From Deothan to Pacharídi the dip is mostly under 30°, the rocks in the southern part of the section being schistose hornblendic gneiss (dome gneiss in the hill north of Deothan) with hornblende schist and rock; these become more schistose to the north-east and pass into mica-schist, above which again is schistose quartzite.

Quartzite is again found to overlie the gneiss in the western part of sheet 8, whilst in the centre of the same the mica-schists are in immediate contact. It may, perhaps, be suggested that the quartzite should be included with the gneiss, and the boundary between the two series drawn above the former, the absence of quartzite in places being thus due to unconformity. It will be found, however, when describing the submetamorphics, that while there is generally, at least, a well-marked junction between the gneiss and quartzite, none such is obtainable between the latter and the schists; it is, however, to be observed, that the junction of the schists with the gneiss is also everywhere one of passage, sometimes gradual, sometimes tolerably sharp, but still a passage; and the foliation of each rock is always, as far as my observations extend, parallel to the common boundary: at least, if there be any deviation it is so slight as to escape detection.

Some local cases have been mentioned above, in which the gneiss overlies the submetamorphics at high angles. Such are, undoubtedly, invertions of the strata, the metamorphics being clearly the lower series. Amongst other examples in which the true superposition of the submetamorphics is apparent, I may mention the Deothan section, the band of quartzite north of Gáwan, and the schists flanking the gneiss hills north of Bhuládi.

Although no unconformity is discernible between the two series in the present area, this does not necessarily militate against the unconformity which has been supposed to exist elsewhere. In the Vindhyans of Central and North-Western India, we have an example of a great formation, which, notwithstanding its age, is undisturbed over large tracts of country; whilst in other areas, like the Dhár Forest, the strata are highly contorted. If on such a formation another great series were deposited, the two would clearly be unconformable to each other, although such unconformity would not be discernible in many places; and if at some subsequent epoch both were greatly disturbed, the resulting relations of the two series to each other would perhaps bear some resemblance to those of the metamorphics and submetamorphics.

Stratigraphy.—If a section be taken from north to south across the Bhiaura range, a little to the west of the trigonometrical station, the following succession of strata is passed over in ascending order—the dip throughout being to the south at high angles, but decreasing somewhat from north to south, the gneiss *b* being nearly or quite vertical, while the mica-schists *k* are inclined at 60° or 70°—

a.—Gangetic alluvium of Bihár.

b.—Gneiss forming dome-shaped hills.

c.—Small band of mica-, with probably some hornblende- schist, fragments of the latter being strewn about.

d.—Quartzite forming the ridge on which the trigonometrical station is situated; some portions are a hard, finely granular rock, breaking with a sub-vitreous fracture, and occurring in beds from one to two or three feet thick, in which no schistose structure is developed; others are coarse-grained and micaceous, and micaceous flaggy beds are also met with.

e.—Hornblende rock and schist, with mica-schist and interbanded layers of quartzite. In some of the hornblende schist the foliated structure is well developed; elsewhere the rock has sometimes a very trappean aspect, and I am not sure that some of it is not trap, either contemporaneous or more probably in dykes parallel to the foliation. A very clear-cut line of demarcation between it and the quartzite is sometimes visible, and that there is more or less trap hereabout is certain from an observation on the top of the ghât which crosses the quartzite ridge north of Phulwaria. Here a band of greenstone, about 15 inches broad, is seen running N. 10° E., or nearly at right angles to the strike of the quartzite. It can only be traced for 10 or 15 feet, but is clearly a dyke.

f.—Quartzite similar to *c*.

g.—Hornblende rock and schist with mica-schist, &c., similar to *d*.

h.—Quartzite similar to *c*.

i.—A very thick band of hornblende rock and schist. Much of it is of the former variety; but the schistose structure is very common also, and the rock sometimes contains a considerable amount of quartz in seam-like nests here and there.

j.—A broad band of schistose, micaceous quartzite. It is coarsely granular, and much softer than the quartzites to the north, so that it does not, like them, rise into a lofty ridge. It contains a good deal of interbanded mica-schist, and the mica-schist to the south (*k*) contain subordinate layers of quartzite, the two rocks not being clearly demarcated from each other.

k.—Mica-schist, passing in places into arenaceous schist, and thence into micaceous quartz schist. No distinct line can be drawn between these, but the main mass of the rock is mica-schist. Along the southern face of the hills it is full of small crystals of garnet and andalusite, the latter sometimes so plentiful as in weathering out to cover the surface with gravel.

l.—Gangetic alluvium of the Sakri valley.

The quartzites *d*, *f*, and *h* of the above section form three lofty parallel ridges (the valleys between being occupied respectively by the beds *e* and *g*), and the possibility of their being in reality the same beds repeated by folding at once suggests itself. Detailed examination of the range, however, did not lead me to adopt this view.

In following the strata towards the west, *e* and *g* are found to disappear, and the three quartzite ridges join into one, in which *d*, *f*, and *h*, may be, and probably are, all represented. The hornblendic band *i* also thins out in the same direction, and where the Sakri river cuts through the range, nothing but quartzite rises above the level of the alluvium, forming a ridge of greatly reduced elevation. A few miles further on, Mr. Medlicott found it gradually to come to an end also.

To the east, again, we find a great twist in the strata at Dhubni, and *e* and *g* can only be traced a short distance beyond this point; hornblende rock, however, is again visible on the top of the ridge east of Mokrumo; *i* and *j* also thin out to the east, so that at Nurpáni H. S. and beyond, the range is again reduced to a single band of quartzite.

It will be observed that all along the Bhiaura range the strike of the foliation of the schists corresponds with the direction in which the different alternations of rocks themselves run. Generally speaking, the bedding and foliation of the mica-schist lie in the same plane, although instances are not unfrequent in which they do not do so. In the former case, the rock has a tendency to weather into more or less slab-like pieces, whilst we find it to split much less easily where the foliation and bedding differ, and to weather into featureless hillocks, like those of Dumduma (sheet 7).

The section across the Ghagra valley is a synclinal, the band of quartzite north of Gáwan being clearly the same as that at Nurpáni. It turns round again in sheet 2 (as observed by Mr. Willson), and re-enters sheet 8, near Gáwan, where it again bends round sharply to south-east. It is here interbanded with hornblende- and mica-schists, the section in this respect resembling that of the Bhiaura range.

There appears to be another synclinal in the Sakri valley below Birne, the quartzites on both sides being, I believe, the same; that on the left, however, is softer and more micaceous, much of it, in fact, verging towards a micaceous quartz schist, and passing insensibly into the mica-schist below. The same rock much mixed with mica-schist, and even gneissose beds, is found again north-east of Píhra, the boundary between it and the metamorphics being a faulted one, indicated along the greater portion of its length by a line of hornstone.

Further south still, the mica-schists are most commonly, but not always, found in direct contact with the gneiss. The rock in the neighbourhood of Rajpura is of a very indefinite character, every gradation from quartzite to mica-schist being found, but too much mixed up to admit of separation. In the western part of the sheet, as I have previously pointed out, the quartzite makes its appearance again, but in the Ratanpur area the schists are the contact rocks, there being here, as elsewhere, a passage, sometimes gradual, sometimes tolerably sharp, into the gneiss. North-west of the above-mentioned village the mica-schist contains abundance of staurolite.

In Mahábar Hill we have the highest member of the series present in this part of the country: a great thickness of quartzite overlying the mica-schists. At the mouth of the Mangraun gorge the junction of the two rocks is well seen, there being a complete passage from one to the other in about 20 yards; half-way between thin layers of both are interstratified. The quartzite forms a great synclinal, dipping everywhere (at the ends of the hill as well as on the flanks) into the hill at angles mostly from 30° to 80°. In the central part of the range the rock is so crushed, that the bedding is sometimes quite obscured. In some cases also, planes of what appear to be cleavage, are visible, having a direction different from that of the bedding. This peculiar trough-like conformation, and the high inclination of the strata, is remarkably favorable to the retention of water, and the volume flowing from the densely forest-clad gorges which wind in amongst the hills, strikes one as exceptionally great.

The absence in the Patru valley of the large thickness of mica-schists, which is present immediately to the south-west, must, I believe, be attributed to a fault with northern downthrow. The junction of the quartzite with the schists however, and of the latter with the gneiss, is natural, so that the fault must occur in the schists themselves. It is apparently by another fault running north and south with western downthrow, that the quartzite is brought almost in contact with the gneiss in the valley north of Kotiyár.

According to the above view, it will be seen that in Northern Hazáribágh the submetamorphics include three main subordinate groups, *viz.* :—

Mahábar quartzite.

Mica-schists, including subordinate bands of arenaceous and hornblendic schists.

Bhiaura quartzite, sometimes wanting, in other places attaining a great thickness, and sometimes interbanded with hornblende- and mica-schists.

PEGMATITE GRANITE.—Through both gneiss and submetamorphics, but especially in the latter, there is a large development of pegmatitic granite,* penetrating the older rocks in

* In most English standard works on geology pegmatite is defined as consisting essentially of quartz and felspar, with little or no mica; and in some, as identical with graphic granite. Delesse, however, and Naumann describe it as a very coarse mixture of quartz, felspar, and silvery mica, often containing tourmaline. It is in the latter sense that the word is used here.

innumerable dykes and veins, as well as in larger masses. The rock is generally a very coarse quaternary compound, composed of quartz, felspar, mica, and tourmaline, united in very varying proportions.

The quartz is white and translucent to semi-transparent, and never, so far as I have observed, presents any approach to crystallization. The felspar is sometimes orthoclase, sometimes albite, the latter having an opaque white color: the orthoclase is also generally white, but of a less pure tint; occasionally it is more or less reddish. The mica (muscovite) generally has a smoke brown color in plates of moderate thickness, although colorless in thin laminæ. When perfectly unaltered and free from internal foreign matter, it is highly transparent, but where decomposed, it loses some of its diaphaniety and acquires a more silvery lustre. The plates occur of every size, up to 18 inches diameter or more, but such very large ones are much less common as those of a few inches across. Occasionally, two minor cleavages are apparent (∞P and $\infty \breve{P}\infty$), parallel to the latter of which more especially, the mineral divides into narrow ribbons, and fibres like asbestos, or, where both are present, it is divided by them into equilateral triangles. Greenish-gray beautifully plumose mica is also not uncommon, weathering out in small irregular masses above the general surface of the rock. Dark-brown and olive-green biotite sometimes occurs, but even where most plentiful, it is quite subordinate to the muscovite, which it never altogether replaces. Occasionally the plates are some inches across, and include smaller interlaminated ones of muscovite.

Tourmaline is rarely entirely absent from the pegmatite, and most usually forms an important ingredient in it. The crystals often attain a large size; those of two and three inches across are common, and in some dykes they are met with over six inches diameter. Owing to the great brittleness of this mineral, in comparison to the felspar and quartz in which it is imbedded, crystals approaching perfection are rarely obtainable; the few I did secure were of the common form $\infty P2. \infty R. - \frac{1}{2}R.$ Sometimes the prisms lie parallel to each other and perpendicular to the walls of the vein, but this is far from being universal, or even common, and it seems, as might be expected, to be more usually observable in dykes of a few feet in thickness. The tourmaline is jet black with brilliant lustre, and the large lumps often met with in the mica mines are superficially not unlike anthracite; some of the miners who have seen the K a r h a r b á r i coal-field take them to be coal, but few of them have any idea of what real coal is like. Small crystals of tourmaline are sometimes found imbedded in plates of mica, with their principal axis parallel to the cleavage of the latter; crystals are again observable penetrating others of the same species. It appears that the tourmaline was generally the first to crystallize, the mica next, afterwards the felspar, and the quartz to have resulted last.

The relative proportions of the different minerals vary greatly; generally all four are present, but in some places the rock consists chiefly of felspar and mica with little quartz, in others it is made up entirely of quartz and mica, and the latter again diminishes in amount until the rock passes into micaceous or into pure vein quartz. Graphic granite, composed of felspar with a little quartz, is another variety occasionally met with. Sometimes the tourmaline is absent, in other cases it is one of the most prominent constituents of the rock.

The pegmatite, as a whole, is very largely crystallized, but one of its most marked characteristics is its *unevenness* of texture. In one place it may be comparatively fine, but here within a few feet a great mass of pure felspar, with cleavage faces a foot long, occurs, and there another of translucent quartz, or perhaps these contain plates of mica over a foot across. It is worthy of note that the coarsest pegmatite often occurs in dykes of only a few yards in breadth, not in the large granitic masses, and it is in the dykes consequently that nearly all of the mica mines have been sunk.

Occasionally the granite occupies considerable areas, as south of Píhra, where in a large mass of irregular hills no other rock is seen, and again south of Gáwan; for a mile below Sánkh the Sakri river flows continuously through it. Most commonly, however, it is found penetrating the older rocks in dykes and veins, varying from 50 yards or more in thickness, down to less than an inch. These are more usually roughly parallel to the foliation of the rocks they penetrate, but by no means universally so. Many cut through quite obliquely and irregularly, and ramify in various directions. They are mostly vertical or hade at high angles (agreeing in this respect with the foliation), but instances occur where they are nearly horizontal. Such horizonal dykes of greater thickness than usual may perhaps, in some cases, give rise to the larger granitic areas.

The surrounding rocks seldom present much appearance of alteration in the vicinity of the granite; generally the junction is quite sharp, and the beds in immediate contact not different from what they are at a distance. It is to be remembered, however, that these beds had perhaps already undergone metamorphism before the introduction of the granite. Sometimes there is a rapid passage of a few inches from one rock to the other, as if the strata in immediate proximity had been fused or greatly softened. South of Píhra, the mica-schists south of the large spread of granite there, pass into gneiss near the junction; but as there is always a gradation from the mica-schist into the true metamorphics in this portion of the country, it does not follow that the above passage is in any way connected with the granite.

After an examination of the granite in the innumerable dykes and veins, presenting every appearance of having forced its way in uneven and ramifying courses through the circumjacent strata, one can scarcely avoid feeling satisfied as to its truly intrusive origin, and the fact of its maintaining a constant mineral character amongst the different rocks through which the dykes occur, whether these be gneiss, mica-, hornblende-, or quartz-schist or even limestone, some of which are rocks from which the granite could not possibly have been produced by any mere chemical re-arrangement, leaves no escape from this view. It is, however, on the other hand, not easy to explain the occurrence of thin strings of granite of an inch or half an inch thick, running exactly parallel to the foliation of the including mica schist for many yards, and at a distance from any visible dyke, and of lenticular pockets (also parallel to the foliation) completely isolated to all appearance in the surrounding rock. Such cases are so very common, that I scarcely think it is always a sufficient explanation to say that they are offshoots of some dyke hidden beneath the surface, or were once connected with a dyke above, which has since been removed by denudation. I have already alluded to the passage of the granite into vein quartz. These are points requiring elucidation, but that the granite is really intrusive is beyond question.

The dykes are far more plentiful in the submetamorphic than in the metamorphic series, and their distribution in the former is very unequal. In some areas they occur, large and small, by hundreds; in others they are entirely wanting.

Mica Mines.—It is in this granite that the well-known mica mines of Bihár* and the neighbouring districts are situated. I have previously said that the coarsest pegmatite is frequently found in dykes of moderate thickness, in which, therefore, plates of mica of the largest size occur, and it is such dykes that the miners generally select for their operations. They pay from one to two rupees each per annum, according to the richness of the yield, to the owner of the land for the privilege of mining. The usual mode of working is simply to excavate a trench along the course of the dyke, which in the Gáwan neighbourhood is seldom carried deeper than 20 or 25 feet. Sometimes where there is a considerable thickness

* A paper by Captain Sherwill on the mode of working the mica mines in the Bihár district may be found in the Journal Asiatic Society, Bengal, vol, XX, p. 295

of decomposed mica near the surface, rude shafts are sunk to the fresh and uninjured mineral, and excavations carried on laterally from the bottom. In a few cases also, rough horizontal galleries are driven in from the side of a hill. In the last methods of course artificial light is necessary. No precaution is taken to support the roof, and accidents are not unfrequent from its falling in.

The plates of mica are generally brought to the miners' village, and there, after being slightly trimmed with ordinary grass-cutting knives, (which are not particularly well adapted for the purpose, but are probably the only ones the people are able to purchase,) they are sorted into different heaps according to quality and size. The quality depends on the mineral being in a perfectly unaltered condition, its transparency and freedom from cloudiness caused by internal foreign matter, the absence of minor cleavages which render it liable to split into ribbons and triangles, and the planeness of its fissile surfaces. Six kinds are recognised according to the size of the plates, *viz.* :—

1st.—Sanjhla.	*4th.*—Karra.
2nd.—Manjhla.	*5th.*—Urtha.
3rd.—Rási.	*6th.*—Admalla.

Some of the miners intercalate failurtha between urtha and admalla, and speak of another size (barka) still larger than admalla. All these terms are used rather vaguely in respect to the absolute size of the plates indicated thereby. At Dháb and Jamtára I induced the miners to separate a quantity of the mica into the different grades, and measured an average specimen of each, with the following results :—

	Dháb.	Jamtára.
Sanjhla	5″ × 4″	4″ × 3″
Manjhla	7 × 5	5 × 4
Rási	9 × 6	6 × 5
Karra	12 × 9	8 × 6

The above four sizes include the greater portion of the mica found, it being only in the best mines that urtha and admalla are procurable. The largest plates I have myself seen measured 19″ × 14″ and 20″ × 17″ inches, but I was informed that considerably larger ones are sometimes obtained.

The mica is sold by the load, which is built up of the plates, either into one frustrum of a cone and carried on the head, after being bound together with cord, or into two such, and carried in a bánghi. A load equals 6 paserís, one paserí being equal to 5 kacha sírs of 12 chatáks each, or to 3¾ paka sírs of 16 chatáks; the load, therefore, being 22½ sírs paka, or 46lbs. avoirdupois. The miners informed me that the prices paid to them by the mahájans were as follows :—

	Per load.
Sanjhla	3 annas,
Manjhla	5 „
Rási	7 „
Karra	12 „
Urtha	2 to 6 rupees,
Admalla	4 to 9 „

the selling prices being about double the above.

The value of the large plates more especially varies greatly with the quality. I was informed by Colonel Boddam that plates of first quality of 18 inches diameter fetch as much as 60 rupís a mánd in the market, or about 30 rupís a load.

Accessory Minerals: Lepidolite.—Accessory minerals are not very numerous. Amongst those which occur, the most abundant is lepidolite, which, although not widely distributed, exists in considerable quantity where it does appear. I first observed it in a dyke a little to the south-west of Píhra, where the granite is composed of white felspar, quartz, and irregular masses of lepidolite occurring as a scaly aggregate, varying in color from violet-red to greyish-violet. The mineral is also found of a lead-grey and violet-grey color, mixed with quartz. An analysis of the violet-red variety by Mr. Tween yielded the following results:—

Silica	50·39
Alumina	31·63
Oxide of Manganese	tr.
Lithia	3·71
Potash	1·40
Soda	5·80
Fluorine	5·00
Loss on igniting	4·23
	102·16

Small black grains and crystals of tinstone are occasionally discernible in both the above varieties. Lepidolite is also met with in a dyke a little to the south-east of this locality; also just north of Bhuládi, and again about a mile south of Manimundar, where the sides of a hillock are strewn with blocks, one of which was estimated to weigh about 8 cwt.

Green and blue Tourmaline.—At the two first-mentioned localities associated with the lepidolite is tourmaline, which varies in color from green to indigo-blue; some crystals being blue in the interior and green externally. The prisms chiefly traverse, parallel to the cleavage, the plates of a silvery mica (altered muscovite?) which is present as well as the lepidolite; they also penetrate the quartz.

Beryl, garnet, apatite, leucopyrite.—Small crystals of yellow beryl are abundant in a large dyke which crosses the Tendwáha Nadi south of Mahábar hill; and garnets, generally much decomposed, are not unfrequently met with here and elsewhere. The few obtained, in which the form was apparent, were trapezohedrons. In three or four dykes a crystal or two of green apatite was observed; and from a dyke crossing the Sakri above Sánkh I obtained a mass of leucopyrite, weighing about three-fourths of a pound.

Tin.—Most of the above minerals being frequent associates of tinstone, their occurrence led me to keep a sharp look-out for such, both in the granite itself and in the river beds. With the exception of that disseminated through the lepidolite of Píhra, I only observed the mineral in one locality however. This was in a lenticular pocket of granite, included in mica-schist, at Simratari, west of Píhra, through which a few crystals of $\frac{1}{8}$ inch across and less were scattered. The occurrence of tin, even in such minute quantity however, is interesting, as showing that the same mineral association which has been observed in other parts of the world obtains here also; and indicates at least the possibility of the ore being found in larger amount in the granite of the area yet to be examined. I fear the chance is but small of its being obtained in workable quantity. The tin-ore of Leda, as previously mentioned, occurred as a bed in the gneiss of the metamorphic series.

Galena.—Galena is very sparsely disseminated through a granite vein, penetrating the limestone and associated beds in the Patru Nadi as well as through the latter beds themselves.

Trap Dykes.—Two or three trap dykes were observed intersecting the granite south of Gáwan. Whether these be of the same age as those which traverse the metamorphic and submetamorphic series is not certain, although there is no assignable reason for supposing them different.

TÁLCHÍRS.—In the Sakri Nadi, south of Dábar, there are some small patches of slightly micaceous buff sandstone, rather fine-grained, but containing abundant rolled pebbles and small boulders of granite, gneiss, mica-schist, &c. In parts, the greater portion of the rock consists of pebbles, in other places it is quite free from them. The beds, which are not more than 20 feet thick in all, are level as a whole, but rolling on a small scale, and are lithologically perfectly similar to Tálchírs. Mr. Willson, however, higher up the same stream, as well as in other places, found *two* sandstones, the upper resting unconformably on, and containing numerous pebbles of the lower, which is clearly Tálchír. It is not perfectly certain to which of these the sandstone in question belongs, but as I observed no sandstone pebbles in it, it is most probably Tálchír. Small patches of similar rock are found south of Deothan and east of Píhra.

DESCRIPTION OF PLATE.

Fig. 1.—Granite dyke resting on, and including a folded mass of, quartz-schist: Section—Tendwáha Nadi, south of Mahábar hill.

„ 2.—Mass of quartz-schist nearly enclosed by granite: Section—Tendwáha Nadi.

„ 3.—Junction between hornblende-schist and granite dyke: Plan—Tendwáha Nadi.

„ 4.—Granite dyke in mica-schist: Section—Sakri Nadi east of Sánkh.

„ 5.—Lenticular pockets of granite, running parallel to the foliation of the surrounding mica-schist: Plan—Simratari.

„ 6.—Granite dyke, in hornblende- and quartz-schist: Section—Tendwáha Nadi.

„ 7.—Granite overlying mica-schist, both of which are faulted against Tálchír sand stone; the newer rocks being covered by alluvium: Section—Sakri Nadi, south of Dábar.

„ 8.—Granite vein in quartzite: Section—S. S. E. of Lakráhi.

„ 9.—Granite dyke cutting obliquely through gneiss, into which it sends strings parallel to the foliation: Plan—E. of Gidhaur hill.

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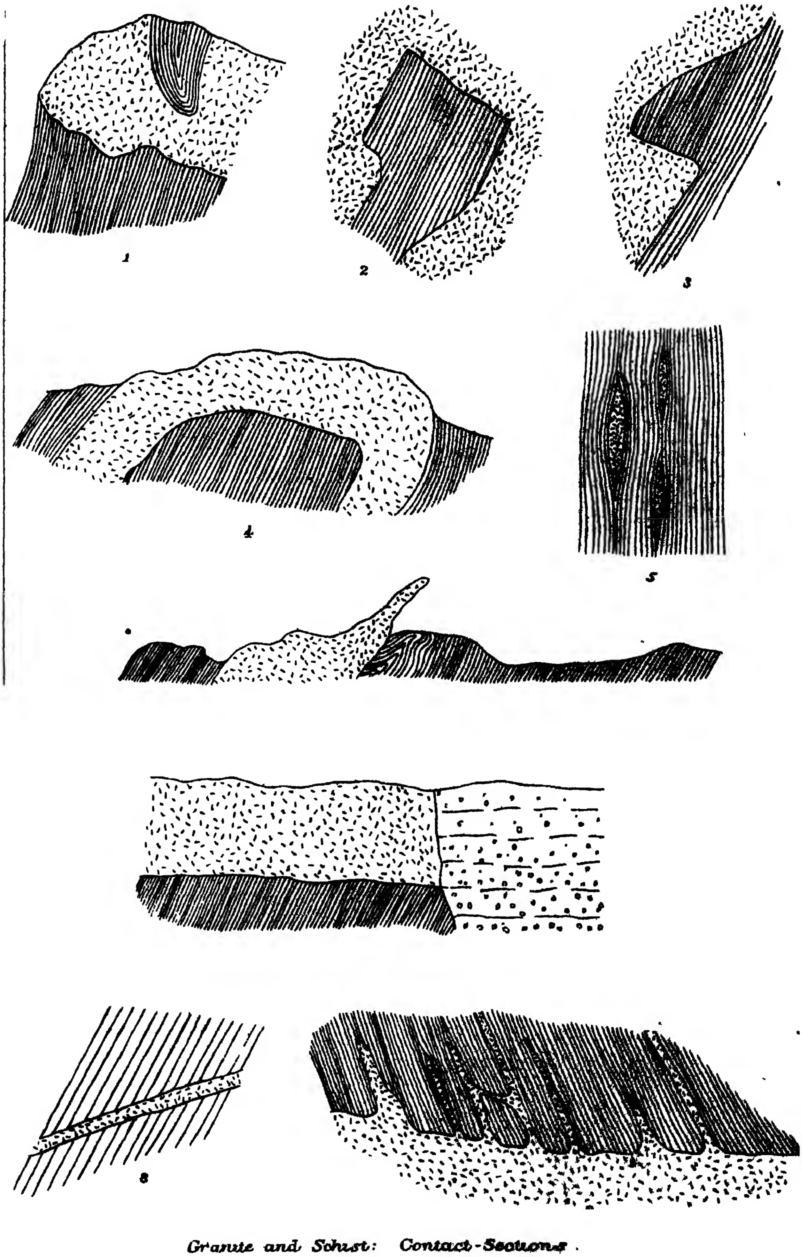

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